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Ground-Water Hydrology and Water Quality of the Southern High Plains Aquifer, Cannon Air Force Base, Curry County, New Mexico, 1994–2005

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U.S. Department of the Interior
U.S. Geological Survey

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Prepared in cooperation with the U.S. AIR FORCE, CANNON AIR FORCE BASE

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Contents

Figures

Tables

Abbreviations

Cannon AFB	Cannon Air Force Base
MDL	method detection limit
min	minute
µg/L	micrograms per liter
mg/kg/day	milligrams per kilogram per day
mg/L	milligrams per liter
µS/cm	microsiemens per centimeter at 25 degrees Celsius
NPDES	National Pollutant Discharge Elimination System
NWIS	National Water Information System
ppb	parts per billion
RCRA	Resource Conservation and Recovery Act
RL	reporting level
SDWA	Safe Drinking Water Act
SWMU	Solid Waste Management Unit
TOC	total organic carbon
USGS	U.S. Geological Survey

Conversion Factors and Datums

Multiply	By	To obtain
inch	2.540	centimeter (cm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
acre	4,047	square meter (m^2)
gallon (gal)	3.785	liter (L)
gal/min	0.06309	liter per second (L/s)

Temperature in degrees Celsius (°C) can be converted to degrees Fahrenheit (°F) as follows:

°F = (1.8 x °C) + 32

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88).

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

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Abstract

In cooperation with the U.S. Air Force, the U.S. Geological Survey has collected hydrologic data about the Southern High Plains aquifer at Cannon Air Force Base in east-central New Mexico since 1994. Under the guidance of the State of New Mexico, ground-water quality of the aquifer has been analyzed as part of annual monitoring at regulated sites at the base. This report provides a summary and interpretation of all available hydrologic data collected by the U.S. Geological Survey for Cannon Air Force Base environmental managers for the regulated sites of Landfill 5 and the Sewage Lagoons between 1994 and 2005.

Cannon Air Force Base is in the Southern High Plains physiographic region, and saturated deposits of the Ogallala Formation underlying the base are within the western boundary of the Southern High Plains aquifer. The general direction of ground-water flow in the Southern High Plains aquifer at Cannon Air Force Base is from northwest to southeast. In 1962, ground water predominantly flowed northwest to southeast with minimal change in direction. Ground-water altitudes declined from 1962 to 1997, and a pronounced water-level recession (area of receding water level) developed northwest of the base, altering flow direction in this area. The recession northwest of the base and the subsequent change in direction of ground-water flow are indicative of local ground-water withdrawals upgradient from Cannon Air Force Base.

Historical water levels in wells within a 3-mile radius of Cannon Air Force Base declined in 52 of 56 wells for various periods of record between 1962 and 2004. Forty-three of the wells indicated strong linear decreases with time, and the largest decline was 91.80 feet, an average annual decline of about 2.13 feet per year. Water levels in monitoring wells at Cannon Air Force Base reflected the regional decline; water levels declined for all wells with periods of record greater than 1 year, and the decreases were strongly linear. From 1994 to 2005, rates of declining water levels at the base ranged from 1.45 to 1.64 feet per year near the Sewage Lagoons and from 2.24 to 4.01 feet per year near Landfill 5. The largest variation in water levels at Cannon Air Force Base was observed in wells C, D, and S, which are located adjacent to Landfill 5 near the southern boundary of the base and near an irrigation well immediately south of the base boundary. Water levels in these wells indicated a pattern of summer water-level decline followed by partial winter water-level recovery, which was likely a result of drawdown and recovery during the irrigation and nonirrigation seasons.

Ground-water sampling by the U.S. Geological Survey from 1994 to 2004 at monitoring wells associated with Landfill 5 and the Sewage Lagoons indicated temporal and spatial differences in water quality. At least one anthropogenic compound was detected in each monitoring well, but all concentrations detected were small and less than U.S. Environmental Protection Agency drinking-water standards. Anthropogenic compounds detected were either pesticide or industrial compounds. Perchlorate was detected in at least one sample from every well for which perchlorate was analyzed, and the source of perchlorate is likely natural and a result of atmospheric deposition. Trace-element concentrations in raw (pretreatment) ground water at Cannon Air Force Base were generally less than drinking-water standards (applicable to posttreatment samples), but maximum concentrations of aluminum, iron, and manganese exceeded secondary drinking-water standards, and maximum chromium concentrations exceeded the primary drinking-water standard.

Spatial and temporal differences of nitrate, major ions, and specific conductance indicated anthropogenic and natural influences on the Southern High Plains aquifer at Cannon Air Force Base. Larger nitrate concentrations decreased in ground water near the Sewage Lagoons during and following decommissioning of the lagoons, and concentrations decreased to levels detected in ground water in wells not affected by the infiltrated wastewater. Similar cation/sulfate ratios were present for ground water from nearly all wells, except for samples from certain wells along the southern boundary of the base and the background well for the Sewage Lagoon monitoring. Temporal changes in specific conductance also indicated the declining influence of the Sewage Lagoons but additionally provided evidence of natural spatial differences in water quality at Cannon Air Force Base similar to major-ion results. Spatial differences in major ions and specific conductance indicated that ground water at Cannon Air Force Base is likely a mixture of multiple sources from different formations or recharge areas.

Introduction

In 2005, Cannon Air Force Base (Cannon AFB) environmental managers implemented a study to review and summarize hydrologic data that were collected by the U.S. Geological Survey (USGS) at a landfill and two sewage lagoons located on the base. In cooperation with the USGS, hydrologic data were compiled and analyzed for spatial and temporal differences. The interpretation of data collected at these sites provides a characterization of the Southern High Plains aquifer that Cannon AFB environmental managers can use for future planning efforts to protect the aquifer and ensure continued operation of all current (2006) activities. Analysis of hydrologic data collected at Cannon AFB provides an overview of the aquifer, the possible anthropogenic influences on the system from past and current operations, and differences in water quality that may be attributed to natural influences.

Cannon AFB is in Curry County, New Mexico (fig. 1), about 5 mi west of Clovis, New Mexico, at an average altitude of 4,295 ft. The base was originally established in 1942 as a U.S. Army air base following the use of the airfield as the Clovis Municipal Airport. The U.S. Army air base was deactivated in 1947, then reactivated in 1951 as a U.S. Air Force base. In 2004, more than 4,000 active military and civilians were employed at Cannon AFB in support of the 27th Fighter Wing and its F-16 aircraft.

In 1994, the USGS, in cooperation with Cannon AFB, began monitoring ground-water levels and ground-water quality at a Resource Conservation and Recovery Act (RCRA) regulated site, Landfill 5, and a National Pollution Discharge Elimination System (NPDES) regulated site, Sewage Lagoons (fig. 2). From 1994 to 2005, the USGS collected data from an increasing network of monitoring wells at these two sites (fig. 2). The monitoring data were provided annually to Cannon AFB for submittal of ground-water-level and ground-water-quality data to the State of New Mexico to meet RCRA and NPDES regulatory requirements. Ground-water monitoring at these sites entailed ground-water sample collection from the unconfined aquifer at Cannon AFB, which is part of the western extension of the Southern High Plains aquifer in the Ogallala Formation.

Landfill 5 is a designated solid waste management unit (SWMU-113) at Cannon AFB and is monitored under RCRA regulations. The landfill was operated from 1968 to 1988 and was used to dispose of domestic solid waste, waste oils and solvents, paint strippers and thinners, pesticide containers, and empty cans and drums (Cannon Air Force Base, 2002). The Sewage Lagoons (SWMU-101) were constructed in 1966; discharge of treated wastewater from the Cannon AFB wastewater-treatment plant to the lagoons ceased in 1998. The lagoons consisted of two unlined surface impoundments that operated in series and received a combination of treated sanitary and industrial wastewater from base facilities (Tetra Tech EC, Inc., 2005). Following closure of the Sewage Lagoons in 1998, the area was allowed to remain undisturbed until 2003 when the remaining sludge was removed from the north lagoon and consolidated with material in the south lagoon. A protective cover and a biotic barrier were constructed as corrective actions for closing of the lagoons (Tetra Tech EC, Inc., 2005). Treated wastewater from the updated base treatment plant was diverted to Playa Lake (fig. 2) during closure of the Sewage Lagoons. With closure of the lagoons, monitoring wells in the Sewage Lagoons area are also used for monitoring of Playa Lake.

Purpose and Scope

This report describes the ground-water hydrology and water quality of the Southern High Plains aquifer at Cannon AFB. Description of the aquifer is based on available results of USGS ground-water monitoring from 1994 to 2005 of Cannon AFB monitoring wells at Landfill 5 and the Sewage Lagoons and associated background wells. Additionally, ground-water-altitude data are presented for a 3-mi radius around the base to examine the hydrologic properties of the aquifer at Cannon AFB in relation to the regional aquifer properties. All data are presented in the context of the Southern High Plains aquifer at Cannon AFB and the surrounding area. To assist future planning efforts for use and protection of the aquifer, this report provides Cannon AFB environmental managers a summary of hydrologic data collected at Landfill 5 and the Sewage Lagoons, an overview of the Southern High Plains aquifer at Cannon AFB, the possible anthropogenic influences on the aquifer from past and current operations, and differences in water quality that may be attributed to natural influences.

Description of the Study Area

Cannon AFB is in the Southern High Plains physiographic region (Fenneman and Johnson, 1946) and lies atop a large plateau known as the Llano Estacado, which slopes gently to the east-southeast from eastern New Mexico into west Texas (Fahlquist, 2003). Topography at Cannon AFB is open and mostly flat and slopes gently to the southeast. No natural surface-water bodies are located on the base except minor ephemeral channels. Manmade ponds are located at the golf course (fig. 2) and the wastewater-treatment plant (Playa Lake). Cannon AFB is in the Plains-Mesa Grassland vegetation unit (Dick-Peddie, 1993), and natural vegetation typically consists of grasses and shrubs.

Cannon AFB is located within a semiarid region (Tuan and others, 1969). A weather station in nearby Clovis receives an average of about 17 inches of precipitation a year; average minimum and maximum temperatures are 43 and 72 degrees Fahrenheit (Western Regional Climate Center, 2005a). Most precipitation falls during the summer months, and much of the annual precipitation likely is lost to evapotranspiration. Annual pan evaporation at the weather station in Clovis averages 86.64 inches; evaporation is largest from May through August (Western Regional Climate Center, 2005b).

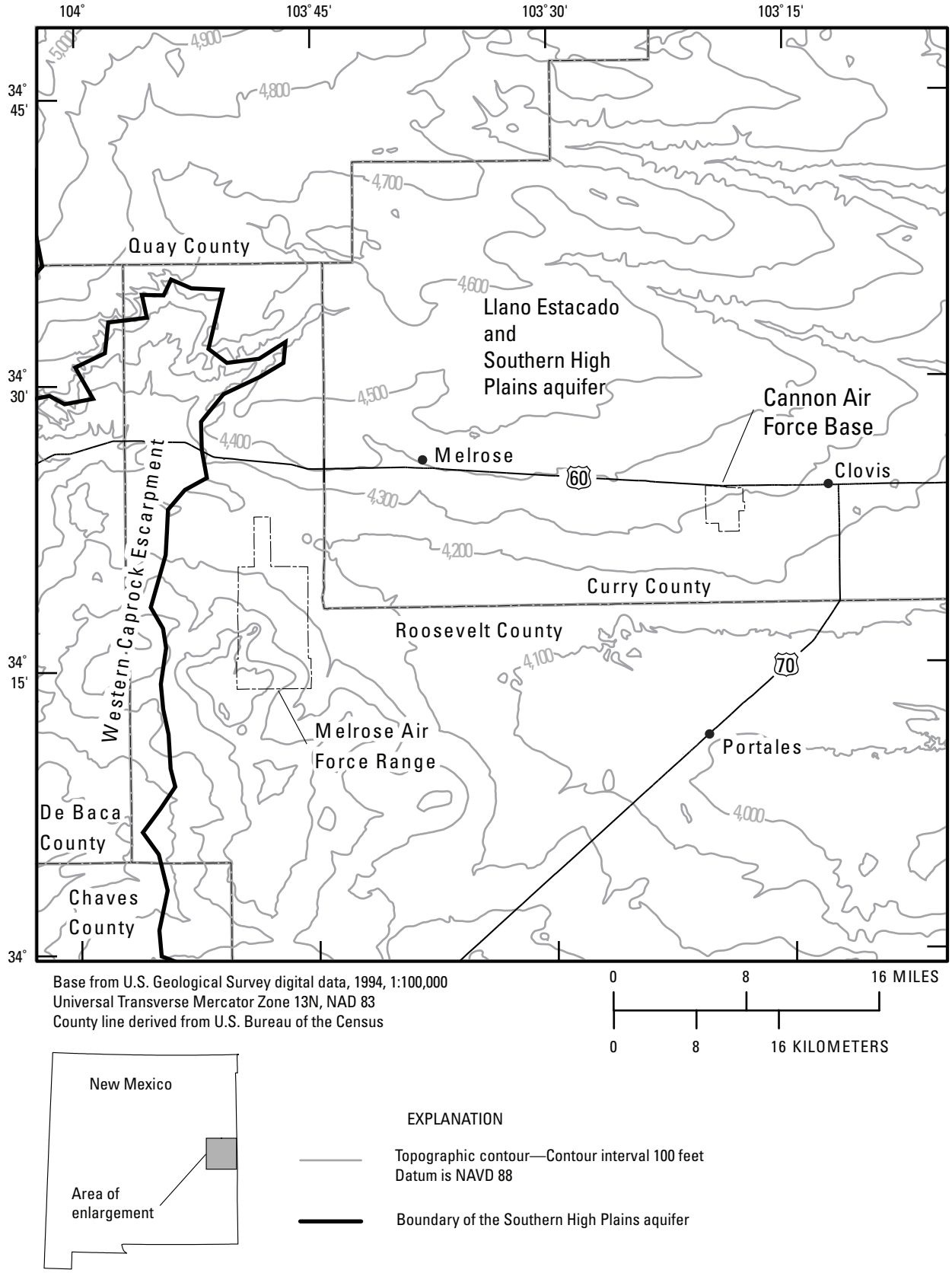

Figure 1. Location of Cannon Air Force Base.

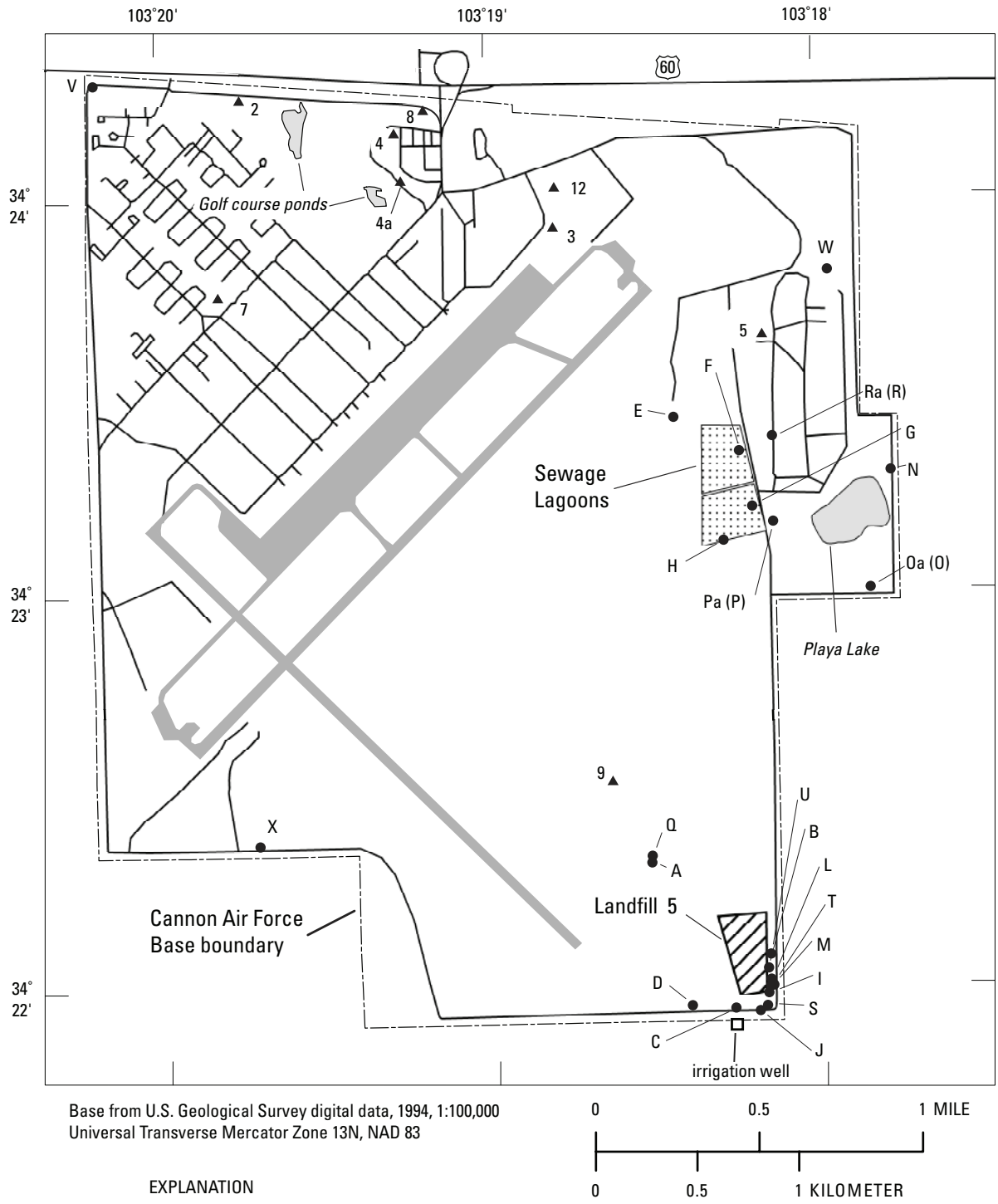

Figure 2. Location of monitoring and production wells at Cannon Air Force Base.

The base is located in the Curry County ground-water basin as designated by the State of New Mexico for the Southern High Plains aquifer in New Mexico (New Mexico Office of the State Engineer, 2005). Water used at Cannon AFB is supplied by nine production wells on the base (fig. 2). From 1998 to 2003, annual pumpage from the production wells ranged from 416,787,600 (1999) to 502,524,600 (2000) gal. A total of 433,232,100 gal was pumped in 2003 (Earth Tech, Inc., 2005). Wells 2, 3, 5, 7, 8, and 12 supply potable water, and well 4 currently (2006) is offline. Well 4a supplies water to the golf course ponds, and well 9 is used solely for fire suppression supply (MWH, 2004).

The subsurface geology of the Southern High Plains aquifer at Cannon AFB includes the Chinle,[1] Ogallala, and Blackwater Draw Formations. The Chinle Formation of Triassic age forms the bottom of the unconfined Southern High Plains aquifer in this area, consists mostly of clay with some intermixed sand and silt, and ranges in thickness from 0 to 400 ft in eastern New Mexico (McGowen and others, 1977). The Ogallala Formation of Tertiary age is the main water-yielding unit of the Southern High Plains aquifer and lies unconformably atop the upper unit of the eastward-dipping Chinle Formation (Dutton and others, 2001). The Ogallala Formation consists of eolian sand and silt and fluvial and lacustrine sand, silt, clay, and gravel (McLemore, 2001) and ranges in thickness from 30 to 600 ft in eastern New Mexico and west Texas (Gustavson, 1996).

The Blackwater Draw Formation of Quaternary age generally overlies the Ogallala Formation at Cannon AFB. The Blackwater Draw Formation is composed mostly of eolian sand deposits and ranges in thickness from 0 to 80 ft in eastern New Mexico (McLemore, 2001). A caliche layer is typically present in the unsaturated zone of the Blackwater or Ogallala Formations in New Mexico (Hart and McAda, 1985). Gustavson (1996) indicated that the caliche forming the Western Caprock Escarpment west of the base (fig. 1) is pedogenic carbonate that accumulated locally during the Tertiary and Quaternary Periods and that other buried caliche layers in the Ogallala Formation are not well known. Drilling at Cannon AFB has indicated that caliche is discontinuous, typically found within 30 ft of the surface, and of variable thickness (Fredrick Gebhardt, U.S. Geological Survey, oral commun., 2004).

The saturated Ogallala Formation deposits at Cannon AFB are within the western boundary of the Southern High Plains aquifer (Hart and McAda, 1985). In New Mexico, the Southern High Plains aquifer is part of the larger High Plains aquifer system that extends from South Dakota to Texas and is commonly referred to as the Ogallala aquifer. The part of the Southern High Plains aquifer in New Mexico is composed of hydraulically connected geologic units of late Tertiary or Quaternary age and is underlain by rocks of Triassic, Jurassic, and Cretaceous age (Hart and McAda, 1985). The unconfined Southern High Plains aquifer in New Mexico is composed primarily of the Ogallala Formation (McLemore, 2001).

The Chinle Formation has informally been divided into upper and lower units (Dutton and Simpkins, 1986; McGowen and others, 1977). The upper unit is mud-rich with discontinuous sand deposits (Dutton and Simpkins, 1986) and contains a confined aquifer that typically produces only 1–2 gal/min of water (Trauger, 1972). The erosional surface of the upper unit of the Chinle creates an uneven contact with the Ogallala. Tertiary deposits filled the valleys, fluvial channels, and uplands of eroded Triassic deposits (Gustavson, 1996). Coarser material was deposited in the paleochannels, and finer sediments were deposited in the interchannel areas (Fahlquist, 2003). Sand and clay layers are known to overlie the Chinle in eastern New Mexico and west Texas, thereby creating zones of variable permeabilities across the Ogallala/Chinle contact (Nativ and Gutierrez, 1988).

The unconformity and variable deposition of sediments at the Ogallala/Chinle contact resulted in differing horizontal lithology with highly variable spatial porosity and permeability. The variable lithology results in a discontinuous aquifer in the Ogallala near the Western Caprock Escarpment that was mapped by Hart and McAda (1985). This discontinuity was not mapped at Cannon AFB and has not been identified during well installation at the base (Fredrick Gebhardt, U.S. Geological Survey, oral commun., 2005) but likely exists west of the base.

The uneven contact of the Ogallala and Chinle Formations also resulted in variable vertical permeabilities. Nativ (1988) found more permeable and less permeable sequences near the Ogallala/Chinle contact in Roosevelt County southwest of the base and variations in water quality in the Southern High Plains aquifer along the Western Caprock Escarpment that were attributed to upward leakage of Chinle water into the Southern High Plains aquifer. Langman and others (2004) described geochemical evidence of leakage from the Chinle into the Ogallala that resulted in different water types in the Southern High Plains aquifer at Melrose Air Force Range, 20 mi west of Cannon AFB.

Recharge to the Southern High Plains aquifer has been estimated to range from 0.01 inch per year (Stone and McGurk, 1985) to 1.71 inches per year (Mantei and others, 1966–1967); most estimates are less than 1 inch per year (Musharrafieh and Logan, 1999). How the aquifer is recharged has been debated, but the current conceptual model indicates that most recharge occurs through playa areas and that interplaya areas contribute little recharge (Scanlon and others, 2003).

Ground water in the New Mexico part of the Southern High Plains aquifer generally is suitable for domestic, municipal, and irrigation uses. The water typically contains large concentrations of calcium, magnesium, and bicarbonate and potentially objectionable concentrations of chloride and fluoride for domestic use (Hart and McAda, 1985). Water from

[1]The Chinle Formation has various accepted names: Chinle Formation, Chinle Formation of the Dockum Group, and Chinle Group (U.S. Geological Survey, 2002). All three names have been used for the geologic description of areas in east-central New Mexico with usage dependent on locally identified units. "Chinle Formation" is used in this report. Locally, this formation is known as the "red beds."

older formations, such as the Chinle, is known to be of lesser quality (Nativ, 1988; Langman and others, 2004).

Farmers began using the Southern High Plains aquifer in the 1940s for irrigation, and about 94 percent of the water pumped from the entire High Plains aquifer in 1995 was used for irrigation (McGuire and others, 2003). Large-scale agriculture did not develop near the study area until the 1950s, but ground-water pumping has occurred since the early 1900s (Musharrafieh and Logan, 1999). In New Mexico, water-level declines in the Southern High Plains aquifer have been smaller than in other States (greater than 150 ft in parts of west Texas), but in New Mexico the saturated thickness of the Southern High Plains aquifer is generally less than 100 ft (year 2000) (McGuire and others, 2003).

Within New Mexico, ground water in the Southern High Plains aquifer generally flows eastward or southeastward (Hart and McAda, 1985), which is considered the overall direction of regional flow in the unconfined aquifer surrounding Cannon AFB. Fifty years of ground-water pumping has created numerous cones of depression that have reversed ground-water flow gradients around heavily irrigated areas (Musharrafieh and Logan, 1999).

Previous Studies

No hydrologic studies have been published for distribution to the public concerning the ground-water resources of Cannon AFB. The USGS and private contractors have submitted data reports to Cannon AFB for submission to the State of New Mexico for compliance with RCRA, NPDES, and Safe Drinking Water Act (SDWA) requirements.

Study Methods

This study was based on data available from USGS monitoring at Cannon AFB that included data from 12 monitoring wells at Landfill 5, 11 monitoring wells at Sewage Lagoons and Playa Lake, and 3 perimeter background wells located along the base boundary and upgradient of these two sites. Additional data include water-level measurements from wells located within an approximate 3-mi radius surrounding the base collected as part of the USGS/State of New Mexico ground-water monitoring program (data published in annual USGS Water Resource Data Reports for New Mexico) and ground-water-quality data provided by Cannon AFB environmental managers for wells N, O, Oa, P, Pa, R, and Ra and the nine production wells sampled by private contractors. Wells used for this investigation are listed in table 1, and periods of record for data collection are listed in table 2. USGS data for wells O, P, and R and their replacements Oa, Pa, and Ra were combined for data analysis. Wells that went dry because of declining water levels and shallow well depths were replaced by deeper wells in the same location with the same well designation but appended with an "a". Water-quality data collected by private contractors for wells N, O, Oa, P, Pa, R, and Ra were submitted to the State of New Mexico for annual/semi-annual monitoring of RCRA-designated sites, and water-quality data for the nine production wells were submitted to the State of New Mexico per SDWA requirements. Data from private contractors were not compiled with USGS data because of differences in sampling and analytical methods. Water-quality data collected by contractors are noted when presented in the text to supplement USGS data when the contractor data may provide insight concerning water-quality differences or conditions.

To examine the decreasing water levels near and at Cannon AFB, changes to water levels were calculated for each well located within an approximate 3-mi radius surrounding the base for which there were three or more water-level measurements in the USGS National Water Information System (NWIS) database (http://nwis.waterdata.usgs.gov/). Data were analyzed for a period-of-record change in water level for wells in the Cannon AFB surrounding area and an annual and period-of-record change for wells at Cannon AFB. Additionally, linear least-squares regression was used to examine the correlation of water-level change and time (R^2 value for strength of relation).

A linear regression's R^2 value indicates how well a trend line fits the water-level data and provides an indicator of model fit or the strength of the relation of the two variables (water level and time). The R^2 values ranged from very small (for example, less than 0.01), which indicates a very poor (nearly random) fit of the trend line to the water-level data, to 0.99, which indicates a very strong correlation of the predicted values (trend line) to the water-level data. An R^2 value cannot solely indicate the predictive value of the regression model but only indicates the strength of the model in explaining the variance of the data. Its value to this analysis is the association of the indicated trend in water level over the period of record as opposed to annual fluctuations possibly associated with local pumping effects or changes to local recharge. A strong relation (R^2 greater than 0.75 was used for this study) between water level and time for a group of spatially diverse wells is indicative of regional changes (decreases or increases in water level) in the aquifer's water table.

The saturated interval of a well is discussed instead of saturated thickness of the Southern High Plains aquifer because the authors cannot confirm that all wells are screened at the bottom of the aquifer. Wells drilled by the USGS at Cannon AFB (L, M, Oa, P, Pa, S, T, U, V, W, and X) penetrate the entire thickness of the Ogallala Formation, and large screen lengths typically were installed because of declining water levels. The remaining monitoring wells at Cannon AFB (wells A–J, N, O, Q, R, Ra, and all production wells) were drilled by contractors hired by the U.S. Army Corps of Engineers. Monitoring wells installed by private contractors were typically specified to reach a set depth and screened across the water table. A review of well logs maintained by the New Mexico Office of the State Engineer for wells in the surrounding area indicated that wells in this area typically penetrate the entire Ogallala Formation, but screen placement was not recorded.

Ground-water-quality sampling by the USGS at Cannon AFB has been motivated by RCRA and NPDES regulatory requirements for the monitoring of Landfill 5 and the Sewage Lagoons. Each site had individual requirements for the constituents to be analyzed, and wells were added to the monitoring network between 1994 and 2005. Where data were available, spatial and temporal differences in water levels and water quality were evaluated. Water-quality data from the 2005 sampling were not included because results had not been received at the time of data analysis. Water-quality data also were compared with SDWA standards established by the U.S. Environmental Protection Agency (USEPA).

SDWA standards provide a useful benchmark for evaluating the quality of ground water for potential water supply. All wells at Landfill 5 and the Sewage Lagoons are for monitoring only, and the production wells at Cannon AFB are used for water supply. SDWA standards are promulgated as posttreatment concentrations, but data collected by the USGS at Cannon AFB were derived from raw (pretreatment and unfiltered) samples for analysis of total concentrations. Comparisons between pre- and posttreatment concentrations can be misleading if the total concentration from the raw sample includes a concentration fraction resulting from suspended material that would not be present if the sample were treated for suspended sediments (such as settling or filtering).

Water-quality constituent concentrations in ground water at Cannon AFB were compared with USEPA primary and secondary drinking-water standards derived for the SDWA. Primary drinking-water standards have maximum contaminant levels (MCLs), are legally enforceable standards for public water systems, and are used to protect public health (U.S. Environmental Protection Agency, 2005b). Secondary drinking-water standards are nonenforceable guidelines for regulating contaminants that may cause cosmetic or esthetic effects in drinking water (U.S. Environmental Protection Agency, 2005b).

Water-quality constituent concentrations in ground water at Cannon AFB are presented with respect to reporting levels (RLs) and method detection levels (MDLs). An MDL is defined as the statistically calculated minimum concentration that can be measured with 99 percent confidence that the reported value is greater than zero; MDLs are determined from replicate analyses of small concentration standards in a typical representative matrix (Oblinger Childress and others, 1999). An MDL is used to control the reporting of false positives. An RL is typically the smallest concentration at which the measurement becomes quantitatively meaningful (quantitation limit) and is usually about three times the MDL (Severn Trent Laboratories, Inc., 2004). RLs are used to reduce reporting of false negatives. Concentrations between the MDL and RL are noted as estimated values.

Ground-Water Monitoring

The USGS measured water levels at Cannon AFB monitoring wells below a known, fixed altitude from 1994 to 2005 by using either an electric tape or steel tape. These water-level data were not published as part of the annual USGS Water Resources Data Reports for New Mexico as were the water-level data collected by the USGS outside of the base boundaries as part of the USGS/State of New Mexico ground-water monitoring program. Water-level data collected by the USGS at Cannon AFB are presented in the "Supplemental Information" section of this report. The USGS collected water-quality samples at Cannon AFB monitoring wells from 1994 to 2004 by using dedicated submersible pumps or a portable submersible pump. All ground-water samples were analyzed at the USGS contract laboratory–Severn Trent Laboratories Denver in Arvada, Colorado. During the study period, USGS sampling of monitoring wells was modified as individual wells were added or dropped, and wells were sampled annually or biannually, depending on regulatory requirements. No samples were collected from well J (table 1) because the well did not contain sufficient water following installation by a private contractor. Water-quality samples were collected and analyzed as total concentrations (unfiltered samples) (table 3).

Quality-assurance procedures were used for water-level measurements and for collection and processing of water-quality samples during the USGS monitoring at Cannon AFB from 1994 to 2005. Prior to purging, repeated measurements were made to ensure that water levels were stable. During purging, field values of specific conductance, water temperature, and pH were monitored in a flowthrough chamber and allowed to stabilize before sample collection. Stable field measurements were used to determine sufficient purge amounts for sampling formation water. Field measurements were deemed stable if a minimum of three or more sequential measurements during a minimum 10-minute period were within the following parameter ranges: specific conductance, +0.3 percent; temperature, +0.2°C; and pH, +0.1 standard unit (Wilde and Radtke, 2005).

Four types of quality-control samples were collected in the field during each sampling trip as part of the USGS monitoring at Cannon AFB: replicates, matrix spikes, field-equipment blanks, and trip blanks. Sequential replicate samples were collected at randomly selected wells—one for a Landfill 5 well and one for a Sewage Lagoons well—to evaluate laboratory precision. Matrix-spike and matrix-spike duplicate samples were collected to ascertain matrix interference. One field-equipment blank was collected to determine the adequacy of cleaning procedures of the portable submersible pump. Trip-blank samples were stored with volatile-organic-compound samples during transport to the laboratory to ensure that outside contaminants were not introduced to the samples. In addition, Severn Trent Laboratories used internal quality-assurance and quality-control practices including the analysis of laboratory-control and method-blank samples with the submitted USGS samples (Severn Trent Laboratories, Inc., 2004).

Table 1. Cannon Air Force Base monitoring and production well information.

[USGS, U.S. Geological Survey; NAVD 88, North American Vertical Datum of 1988; NAD 83, North American Datum of 1983; ft bls, feet below land surface to bottom of well casing; ft, feet; PVC, polyvinyl chloride; NA, not available]

Well identifier (fig. 2)	Well identifier (fig. I-1)	USGS identification number	Land-surface altitude (ft above NAVD 88)	Latitude (NAD 83)	Longitude (NAD 83)	Well depth (ft bls)	Casing material	Screened interval from top of screen (ft)	Top of screen altitude (ft above NAVD 88)
Landfill 5 wells									
A	65	342218103182601	4,263.83	34°22′18.91″	103°18′31.44″	343	PVC	15	3,935.83
B	61	342203103181001	4,262.10	34°22′02.67″	103°18′10.36″	362	PVC	15	3,914.80
C	53	341256103180801	4,263.72	34°21′56.68″	103°18′16.50″	362	PVC	15	3,916.72
D	56	342157103181701	4,261.94	34°21′57.13″	103°18′24.44″	357	PVC	15	3,920.19
I	57	342158103180601	4,261.57	34°21′58.94″	103°18′10.39″	291	PVC	20	3,990.57
J[1]	54	342156103180802	4,261.11	34°21′56″	103°18′08″	NA	NA	NA	NA
L	60	342201103180901	4,261.38	34°22′00.99″	103°18′09.94″	285	PVC	20	4,000.38
M	59	342200103181001	4,261.28	34°21′59.94″	103°18′10.07″	287	PVC	20	3,999.00
Q	66	342219103183101	4,263.50	34°22′18.99″	103°18′31.40″	294	PVC	30	3,999.10
S	55	342157103181101	4,260.72	34°21′57.01″	103°18′10.70″	365	PVC	40	3,976.72
T	58	342200103180901	4,260.82	34°22′00.07″	103°18′09.47″	365	PVC	40	3,976.82
U	62	342205106181001	4,262.27	34°22′04.81″	103°18′09.93″	365	PVC	40	3,978.27
Sewage Lagoons and Playa Lake wells									
E	94	342328103182401	4,279.70	34°23′26.51″	103°18′26.23″	373	PVC	15	3,924.70
F	89	342321103181001	4,274.93	34°23′21.29″	103°18′14.32″	375	PVC	15	3,919.93
G	86	342313103180801	4,276.46	34°23′12.86″	103°18′12.07″	372	PVC	15	3,919.46
H	81	342307103181601	4,275.98	34°23′07.72″	103°18′17.43″	375	PVC	15	3,920.98
N	87	342317103174701	4,265.88	34°23′18.11″	103°17′46.60″	297	PVC	30	3,998.88
O	78	342304103174401	4,269.26	34°23′00.25″	103°17′50.42″	303	PVC	30	3,995.95
Oa	77	342300103175001	4,270.11	34°23′00.33″	103°17′50.60″	365	PVC	60	3,970.11
P	82	342309103180601	4,270.55	34°23′10.43″	103°18′08.02″	300	PVC	20	4,000.55
Pa	85	342310103180801	4,270.85	34°23′10.05″	103°18′08.27″	360	PVC	60	3,875.85
R	NA	Non-USGS well	Decommissioned after construction because of steel pipe used in constructing the well						
Ra	91	342323103180801	4,272.31	34°23′23.50″	103°18′08.23″	311	PVC	30	3,991.75
Perimeter background wells									
V	107	342418103201201	4,324.82	34°24′18.00″	103°20′12.62″	370	PVC	60	4,019.82
W	98	342348103175801	4,296.95	34°23′48.64″	103°17′57.65″	365	PVC	60	3,996.95
X	67	342222103194301	4,264.76	34°22′22.16″	103°19′43.14″	336	PVC	40	3,973.76
Production wells									
2	NA	Non-USGS well	[2]4,306	[2]34°24′15.3″	[3]103°19′44.5″	380	Steel	94.5	[2]4,021
3	NA	Non-USGS well	[2]4,307	[2]34°23′55.5″	[3]103°18′47.4″	402	Steel	87	[2]3,997
4	NA	Non-USGS well	[2]4,313	[2]34°24′10.0″	[3]103°19′16.2″	357	Steel	51	[2]4,010
4a	NA	Non-USGS well	[2]4,316	[2]34°24′02.8″	[3]103°19′15.0″	411	Steel	60	[2]3,965
5	NA	Non-USGS well	[2]4,293	[2]34°23′38.9″	[3]103°18′09.4″	402	Steel	102	[2]4,009
7	NA	Non-USGS well	[2]4,319	[2]34°23′45.4″	[3]103°19′48.8″	382	Steel	90	[2]4,039
8	NA	Non-USGS well	[2]4,321	[2]34°24′13.5″	[3]103°19′11.0″	415	Steel	100	[2]4,020
9	NA	Non-USGS well	[2]4,270	[2]34°22′31.3″	[3]103°18′38.0″	385	Steel	49	[2]3,949
12	NA	Non-USGS well	[2]4,314	[2]34°24′01.5″	[3]103°18′47.0″	410	Steel	50	[2]3,964

[1] Well was drilled by private contractor prior to 1994 but never contained sufficient water for sampling or water-level measurement.

[2] Altitude reported as feet above mean sea level; no datum indicated (Earth Tech, Inc., 2005).

[3] Latitude and longitude of production wells were determined from map placement (Earth Tech, Inc., 2005).

Table 2. Periods of record for Cannon Air Force Base monitoring and production wells.

[USGS, U.S. Geological Survey; NA, not available]

Well identifier (fig. 2)	USGS identification number	USGS water-level/water-quality period of record
Landfill 5 wells		
A	342218103182601	1994-96, 2005
B	342203103181001	1994, 1995, 1999-2005
C	342156103180801	1998-2005
D	342157103181701	1999-2005
I	342158103180601	1994-99
J	342156103180802	No data collected
L	342201103180901	1994-97
M	342200103181001	1994-97
Q	342219103183101	1997-2003
S	342157103181101	1999-2005
T	342200103180901	1999-2005
U	342205103181001	1999-2005
Sewage Lagoons and Playa Lake wells		
E	342328103182401	1994, 1996-2005
F	342321103181001	1996-2005
G	342313103180801	1996-2005
H	342307103181601	1994, 1996-2005
N	342317103174701	1996
O	342304103174401	1996
Oa	342300103175001	[1] NA
P	342309103180601	1995, 1996
Pa	342310103180801	[1] NA
R	Non-USGS well	[1] NA
Ra	342323103180801	[1] NA
Perimeter background wells		
V	342418103201201	2005
W	342348103175801	2005
X	342222103194301	2005
Production wells		
2	Non-USGS well	[1] NA
3	Non-USGS well	[1] NA
4	Non-USGS well	[1] NA
4a	Non-USGS well	[1] NA
5	Non-USGS well	[1] NA
7	Non-USGS well	[1] NA
8	Non-USGS well	[1] NA
9	Non-USGS well	[1] NA
12	Non-USGS well	[1] NA

[1] The full period of record for these wells is unknown. Sampling was performed by private contractors at the request of Cannon Air Force Base according to State of New Mexico requirements. Data from these wells were not grouped with USGS data for analysis. Individual sampling periods for these wells are referenced in the text where the data are used to supplement interpretation of USGS data.

Table 3. Water-quality constituents and laboratory analytical methods for ground-water samples collected at Cannon Air Force Base by the U.S. Geological Survey.

[USEPA/EPA, U.S. Environmental Protection Agency; SW, [1] USEPA Test Methods for Evaluating Solid Wastes; MCAWW, [2] USEPA Methods for Chemical Analysis of Water and Wastes; ºC, degrees Celsius]

Analysis constituent or group	Description	USEPA method[3]
Landfill 5 constituents		
Cyanide		SW846 9012A
Sulfide		SW846 9030B/9034
Organic carbon		SW846 9060
Major cations	Ca, Mg, K, Na	SW846 6010
Perchlorate		EPA 314.0/SW846 8321A
Trace elements	Ag, Al, As, Ba, Be, Cd, Co, Cr, Cu, Fe, Mn, Mo, Ni, Pb, Sb, Se, Sn, Tl, V, Zn	SW846 6010/6020
Mercury		SW7470A
Organic halogens	All organic halides containing bromine, chlorine, or iodine	SW846 9020B
Volatile organic compounds	56 organic compounds with low boiling points (less than 200°C)	SW846 8260B
Semivolatile organic compounds	107 neutral, basic, and acidic organic compounds that are soluble in methylene chloride	SW846 8270C
Dioxins and furans	Polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans	SW846 8280
Polynuclear aromatic hydrocarbons	18 hydrocarbon compounds with multiple benzene rings	SW846 8310
Organochlorine pesticides	24 chlorine-based pesticides	SW846 8081A
Polychlorinated biphenyls	7 mixtures (aroclors) and 7 individual compounds (congeners)	SW846 8082
Chlorinated herbicides	4 chlorinated herbicides	SW846 8151A
Sewage Lagoons and Playa Lake constituents		
Dissolved solids		MCAWW 160.1
Nitrogen, nitrate plus nitrite	Values are nitrate plus nitrite or nitrate, as nitrogen. If both existed for the sample date, nitrate plus nitrite was included and nitrate was excluded.	MCAWW 353.2
Major cations	Ca, Mg, K, Na	SW846 6010
Sulfide		SW846 9030B/9034
Sulfate		MCAWW 300.0A
Perchlorate		EPA 314.0
Trace elements	Ag, Al, As, Ba, Be, Cd, Co, Cr, Cu, Fe, Mn, Mo, Ni, Pb, Sb, Se, Sn, Tl, V, Zn	SW846 6010/6020
Mercury		SW7470A
Volatile organic compounds	56 organic compounds with low boiling points (less than 200°C)	SW846 8260B
Organochlorine pesticides	24 chlorine-based pesticides	SW846 8081A
Polychlorinated biphenyls	7 mixtures (aroclors) and 7 individual compounds (congeners)	SW846 8082

[1] U.S. Environmental Protection Agency (1986).

[2] U.S. Environmental Protection Agency (1983).

[3] All water-quality constituents were analyzed by the USGS contract laboratory, Severn Trent Laboratories Denver in Arvada, Colorado, from unfiltered samples.

Non-Cannon Air Force Base Data

To determine ground-water flow patterns for the Southern High Plains aquifer in the vicinity of Cannon AFB, water-level measurements were retrieved from the USGS NWIS database for an approximate 3-mi radius surrounding the base. Information about these wells is listed in table I-1; well locations are shown in figure I-1, and water levels are listed in table I–2 in "Supplemental Information" (in the back of the report). Excluding the Landfill 5 and Sewage Lagoons wells, about 600 water-level measurements were available for 120 wells in the 3-mi-radius area surrounding Cannon AFB (Cannon AFB area), the earliest recorded in 1954. The majority of water-level measurements were made in January or February, typically before the onset of the irrigation season.

Acknowledgments

The authors acknowledge the support and help from the Pollution Prevention Unit of the Cannon AFB Engineering Department. Peter Zamie, Dennis Timmons, John Rebman, and Don White of Cannon AFB initiated this study and provided useful insight for completion of the study goals.

Ground-Water Hydrology

The ground-water hydrology of the Southern High Plains aquifer in the Cannon AFB area is controlled by recharge characteristics and the contact between the saturated Ogallala Formation and the underlying Chinle Formation. Substantial evapotranspiration likely limits diffuse areal recharge.

The Ogallala/Chinle contact provides the main control for regional flow in the water-table aquifer, and pumping likely has a strong effect on local flow. Ground-water altitudes are discussed for the Cannon AFB area (regional) and Landfill 5 and Sewage Lagoons (local).

Ground-Water Altitude and Direction of Ground-Water Flow

From 1962 to 1997, synoptic water-level measurements were conducted every 5 years in the Cannon AFB area during January through March as part of a USGS cooperative program with the State of New Mexico. The specific wells and number of wells measured varied between synoptic periods (table 4). Synoptic water-level measurements for 1962, 1967, 1977, 1987, and 1997 were sufficient in areal coverage for determining ground-water flow patterns and comparing changes in ground-water altitude in the study area (fig. 3). The general direction of ground-water flow in the Cannon AFB area is from northwest to southeast. In 1962, the direction of ground-water flow in the Cannon AFB area was fairly uniform, and ground water predominantly flowed northwest to southeast with minimal change in direction. Ground-water altitudes declined from 1962 to 1997, and a pronounced water-level recession (area of receding water level) developed northwest of the base, altering flow direction in this area (fig. 3). The declining ground-water altitude in the Cannon AFB area reflects the decline in water levels in the Southern High Plains aquifer as described by McGuire and others (2003).

Table 4. Number of wells measured during each 5-year synoptic measurement in the area surrounding Cannon Air Force Base.

Year of synoptic water-level measurement	Number of wells measured
1962	29
1967	28
1972	31
1977	44
1982	77
1987	74
1992	13
1997	28

Ground-Water Levels in the Area Surrounding Cannon Air Force Base

Ground-water levels have declined substantially throughout the Southern High Plains aquifer since the mid-1940s when ground water was first used for irrigated agriculture (McGuire and others, 2003). In the Cannon AFB area, three or more water-level measurements were made between 1954 and 2004 for 56 of 120 wells with data in the NWIS database (excluding the Landfill 5 and Sewage Lagoons wells). These wells included irrigation, stock, domestic, observation, and unused wells and typically were measured during winter or early spring. The largest water-level decline at a well in the Cannon AFB area was 91.80 ft from 1962 to 2004, an average annual decline of about 2.13 ft per year (well 40, table 5). Water levels in 52 of the 56 wells declined during the various periods of record, and water levels in 43 of the 56 wells indicated a strong linear decrease with time (R^2 greater than 0.75) (table 5).

Comparison of changes in water level between successive 5-year synoptic measurements indicates substantially more wells with decreasing than increasing water levels between each 5-year period (table 6). Wells with the longest records of water-level measurements exhibit minor periods of recovery but a dominant decline in water levels during the past 50 years (fig. 4). The declining regional water-level data likely indicate ground-water withdrawals from the aquifer that exceed recharge. The differences in slope of the declining water levels in the Cannon AFB area indicate a spatial variability (local effects) to the regional decline (fig. 4).

With declining water levels, the saturated thickness of the aquifer in the Cannon AFB area also has decreased. A smaller saturated thickness can reduce the pumping capacity of a well or enlarge the cone of depression around a pump if discharge rates are maintained. The altitude of the bottom of the Southern High Plains aquifer is variable because of the eroded surface of the Chinle Formation, which creates a variable saturated thickness in the Cannon AFB area. Wells in the Cannon AFB area with the longest records of water-level measurements indicate the effect of declining water levels on the saturated interval penetrated by the wells (table 7). The saturated interval at these wells decreased at least 35 percent for all wells, and the largest decrease was about 71 percent (well 40).

Ground-Water Levels at Landfill 5 and the Sewage Lagoons

The USGS has measured water levels in monitoring wells surrounding Landfill 5 and the Sewage Lagoons concurrently with water-sample collection since 1994. Water levels in wells at Cannon AFB reflect the regional decline that was apparent in the surrounding area; water levels declined in all wells during their periods of record except at well X (fig. 2), which had a period of record shorter than 1 year (table 8). The rates of decline in most wells can be separated into two spatial groups. Near the Sewage Lagoons (wells E, F, G, H, N, O/Oa, and P/Pa) (fig. 2), rates of decline ranged from 1.45 to 1.64 ft per year; near Landfill 5 (wells B, C, D, I, L, M, S, T, and U) (fig. 2), rates of decline ranged from 2.24 to 4.01 ft per year. The difference in rates of decline for ground water at the Sewage Lagoons and Landfill 5 was likely a result of local recharge to the aquifer near the Sewage Lagoons from infiltration of treated wastewater

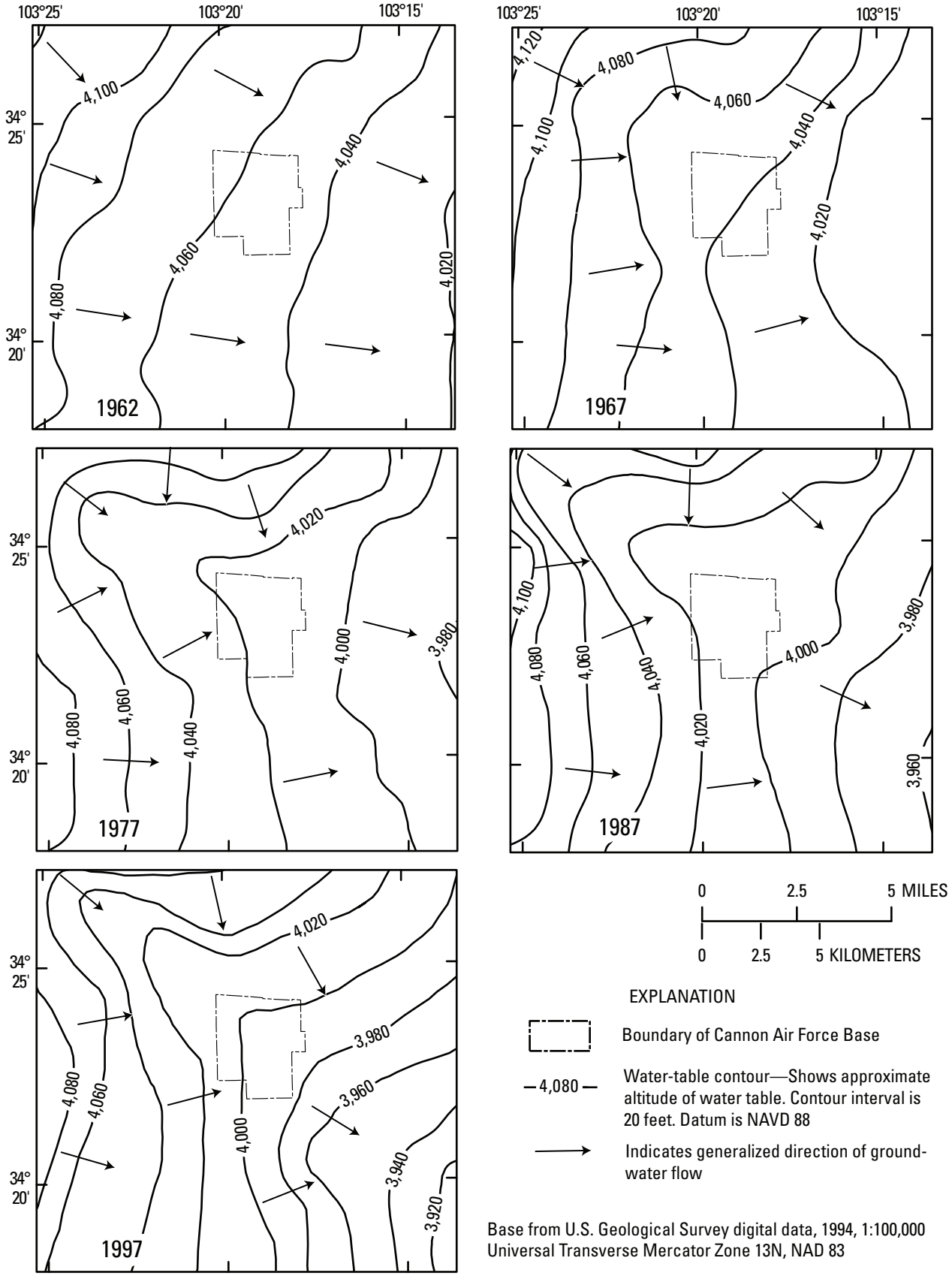

Figure 3. Approximate ground-water altitude and general direction of ground-water flow in the Southern High Plains aquifer in the Cannon Air Force Base area, 1962, 1967, 1977, 1987, and 1997.

Table 5. Measurements and changes in water level for wells surrounding Cannon Air Force Base, 1954–2004.

[R^2, statistical value that describes the proportion of variation in the data explained by the least-squares regression model—water level relative to time]

Well identifier (fig. I–1)	U.S. Geological Survey identification number	First measurement	Last measurement	Number of measurements	Water-level change during period of record[1] (feet)	R^2
1	341903103145601	01/09/80	01/07/87	5	–18.09	0.98
4	341915103180501	01/13/61	01/28/67	3	–4.42	0.99
5	341918103175001	01/13/61	01/28/67	3	–5.52	0.58
6	341919103175001	01/18/77	02/20/97	4	–31.56	0.99
8	341935103145601	01/19/84	01/07/98	14	–46.01	0.93
10	341936103155801	03/13/72	02/19/97	5	–64.57	0.99
13	341944103141001	01/08/94	01/24/97	3	–17.16	0.99
20	342011103191701	01/19/77	01/23/97	9	–29.86	0.95
21	342015103231501	01/21/77	02/06/87	3	–5.96	0.99
22	342025103211601	01/12/60	01/18/72	5	–48.44	0.67
23	342033103155801	02/26/69	03/06/04	29	–81.25	0.98
24	342034103170101	02/26/63	03/12/87	7	–50.77	0.99
25	342034103175101	01/26/77	03/06/04	5	–65.14	0.99
27	342036103201301	12/16/71	03/11/87	4	–11.86	0.99
28	342036103220001	01/10/67	02/20/03	30	–23.06	0.72
31	342047103232001	01/12/61	01/05/77	4	–11.17	0.52
36	342113103173401	07/08/75	01/15/87	3	–16.33	0.99
39	342117103160701	02/27/62	01/07/77	3	–32.95	0.88
40	342121103142301	02/27/62	03/05/04	29	–91.80	0.93
41	342126103164501	01/05/75	01/06/98	23	–45.78	0.96
42	342127103185501	01/16/67	02/09/82	4	–23.52	0.99
45	342135103211402	01/05/77	02/06/87	4	–10.24	0.97
47	342140103190501	02/10/54	03/04/04	39	–61.88	0.94
48	342142103221201	02/17/82	03/14/02	5	0.43	0.00
49	342145103232501	03/08/62	01/05/77	4	–0.81	0.08
70	342232103211801	02/26/82	02/10/87	3	–4.14	0.99
73	342240103175001	02/10/54	01/15/87	7	–44.75	0.96
74	342246103172101	01/12/72	02/11/82	3	–12.44	0.99
75	342246103204201	01/27/77	03/07/97	4	32.89	0.44
79	342306103142101	01/20/67	01/15/87	5	–23.78	0.96
83	342310103160901	01/06/56	01/12/88	28	–35.60	0.87
84	342310103165901	02/10/54	03/04/04	7	–59.60	0.98
90	342323103145601	01/10/83	01/08/98	15	–11.90	0.57
95	342338103203701	01/23/67	03/05/04	7	–45.88	0.89
97	342344103224901	02/17/82	03/13/92	3	1.38	0.06
100	342358103151601	10/27/77	01/15/87	3	–3.85	0.99
102	342404103210401	01/30/67	02/05/87	5	–37.15	0.95
106	342418103180601	02/16/82	02/21/97	3	–10.89	0.97
108	342419103232301	01/05/77	03/07/97	4	–3.99	0.51
111	342442103213601	03/06/62	01/06/79	12	–48.62	0.95
112	342453103141901	01/25/77	01/15/87	3	–1.28	0.99

Table 5. Measurements and changes in water level for wells surrounding Cannon Air Force Base, 1954–2004.—Continued

[R^2, statistical value that describes the proportion of variation in the data explained by the least-squares regression model—water level relative to time]

Well identifier (fig. I–1)	U.S. Geological Survey identification number	First measurement	Last measurement	Number of measurements	Water-level change during period of record[1] (feet)	R^2
114	342456103195201	03/14/62	01/27/87	7	–81.96	0.87
115	342457103213901	01/31/72	01/17/97	13	–32.25	0.52
116	342505103151801	03/03/62	01/06/98	29	–40.90	0.33
120	342519103230101	03/03/62	01/11/86	20	–53.80	0.85
121	342520103165601	04/21/54	01/26/77	11	–50.92	0.96
123	342522103203801	03/03/62	01/31/72	3	–26.81	0.95
125	342532103180501	01/29/82	02/21/97	3	–1.78	0.97
130	342548103193601	03/14/62	03/03/04	29	–32.72	0.57
134	342559103183401	02/23/82	04/03/87	3	12.80	0.99
136	342609103172701	03/16/77	01/13/87	3	–5.27	0.95
137	342615103220701	03/03/62	03/07/97	7	–82.73	0.80
140	342630103145201	04/21/54	02/04/77	12	–32.35	0.90
142	342633103155301	01/06/71	03/11/04	24	–20.52	0.76
143	342638103162401	03/03/62	02/04/77	3	–21.65	0.99
144	342653103195201	01/20/69	01/13/87	5	–14.12	0.97

[1] Periods of record and beginning and ending dates differ among wells, which can affect comparison of water-level changes.

Table 6. Number of wells surrounding Cannon Air Force Base with increasing or decreasing water level between successive 5-year synoptic measurements, 1962–97.

	1962–67	1967–72	1972–77	1977–82	1982–87	1987–92	1992–97
Number of wells	20	19	24	33	65	13	11
Wells with increase	4	1	1	3	12	2	1
Wells with decrease	16	18	23	30	53	10	10

Table 7. Changes in saturated interval for selected wells surrounding Cannon Air Force Base.

[Initial, initial saturated interval in feet and date of water-level measurement; Final, final saturated interval in feet and date of water-level measurement]

Saturated interval[1]	U.S. Geological Survey identification number and map identifier[2] (fig. I–1 and table I–1)				
	342033103155801 (23)	342036103220001 (28)	342121103142301 (40)	342140103190501 (47)	342505103151801 (116)
Initial	153.1 (February 1969)	62.5 (January 1967)	128.7 (February 1962)	100.9 (February 1954)	115.3 (March 1962)
Final	71.9 (March 2004)	39.5 (March 2004)	36.9 (March 2004)	46.0 (January 1998)	74.4 (January 1998)
Overall decrease (percent)	53.0	36.8	71.3	54.4	35.5

[1] Well depth and depth to water from land surface were used to calculate saturated interval.

[2] Well 130 (342548103193601), which is shown in figure 4, did not have a recorded well depth to determine the saturated interval at the well location.

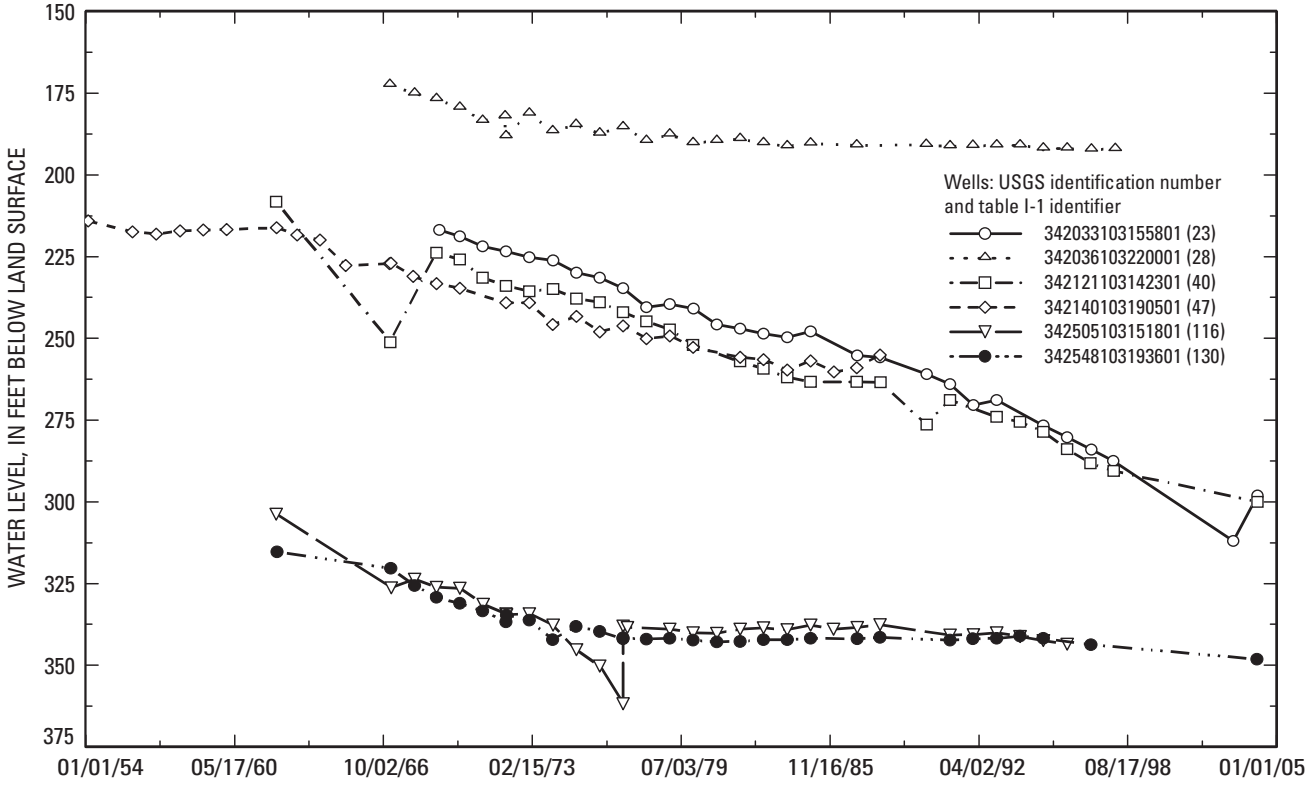

Figure 4. Water level in wells with the longest periods of record in the area surrounding Cannon Air Force Base, 1954–2004.

from the previously used lagoons and the current disposal area (Playa Lake). For all wells with at least three data points and a minimum 3-year period of record, the decline in water levels near Landfill 5 and the Sewage Lagoons was strongly linear (R^2 greater than 0.75) indicating a regional influence that is causing water levels to decline (table 8).

A seasonal variation in water levels was observed in wells C, D, and S, which are adjacent to the southern boundary of Cannon AFB and near an irrigation well immediately south of the base boundary (fig. 2). No production wells for the base are located in this area. Water levels in C, D, and S indicated a pattern of water-level decline during the summer irrigation season followed by a partial water-level recovery during winter (fig. 5). This water-level pattern, however, was not readily apparent or was absent in wells A and Q, which are about 0.4 mi north-northwest of the irrigation well. The influence (cone of depression) of the irrigation well south of the base boundary does not appear to extend beyond the Landfill 5 area.

Saturated Interval of Wells at Landfill 5 and the Sewage Lagoons

The saturated thickness of the Southern High Plains aquifer has decreased at Cannon AFB because of declining water levels (table 7). Wells near Landfill 5 and the Sewage Lagoons with periods of records from the beginning of USGS monitoring indicated decreases equal to or greater than 18 percent in the saturated interval (table 9). The largest declines in water level and largest decreases in saturated interval occurred near Landfill 5 (wells A and B).

Aquifer Recharge

Soil- and ground-water chemistry data collected by the USGS in 2004 for a recharge study was used to determine possible recharge rates and to estimate the ground-water age of the Southern High Plains aquifer at Cannon AFB (Falk, 2005). Chloride concentrations and moisture content of soil samples were analyzed to determine the water infiltration rate through the soil profile and the time required for chloride accumulation. Large chloride concentrations in soil water and long accumulation rates in interplaya areas indicated that diffuse recharge likely is not occurring at Cannon AFB, but small chloride concentrations in soil water below a stormwater detention area indicated that focused recharge is likely contributing to the aquifer (Falk, 2005). Additionally, concentrations of chlorofluorocarbons in ground water were measured to determine the apparent age of the water. The apparent ages, which are model ages uncorrected for physical and chemical processes that can affect chlorofluorocarbon concentrations (Plummer and Busenberg, 2000), ranged from 25 to 50 years old. The presence of chlorofluorocarbons in ground water indicates that the aquifer has been recharged since the 1940s,

Table 8. Measurements and changes in water level for wells near Landfill 5 and the Sewage Lagoons at Cannon Air Force Base, 1994–2005.

[R^2, statistical value that describes the proportion of variation in the data explained by the least-squares regression model—water level relative to time); NA, not applicable—data set has less than 3 years of record]

U.S. Geological Survey identification number	Well Identifier (fig. 2)	First measurement	Last measurement	Number of measure-ments	Water-level change (feet per year)	Water-level change during period of record[1] (feet)	R^2
342218103182601	A	02/21/94	01/10/05	16	–2.46	–27.06	1.00
342203103181001	B	02/21/94	01/10/05	35	–2.97	–32.64	0.98
342156103180801	C	04/06/98	01/10/05	14	–2.29	–16.06	0.82
342157103181701	D	03/02/99	01/10/05	13	–2.24	–13.46	0.93
342328103182401	E	09/13/94	01/10/05	20	–1.59	–17.44	0.98
342321103181001	F	09/12/94	01/10/05	20	–1.60	–17.65	0.96
342313103180801	G	09/13/94	01/10/05	19	–1.64	–18.02	0.98
342307103181601	H	09/13/93	01/10/05	20	–1.55	–18.65	0.98
342158103180601	I	02/21/94	02/28/00	15	–3.21	–19.28	0.98
342201103180901	L	02/21/94	08/19/97	10	–4.01	–12.03	0.99
342200103181001	M	02/21/94	08/06/98	11	–2.60	–10.40	0.96
342317103174701	N	06/27/95	01/10/05	8	–1.45	–14.45	0.95
342300103175001	Oa	02/29/04	01/10/05	5	NA	–2.53	NA
342304103174401	O	06/27/95	02/27/96	2	NA	–0.06	NA
342309103180601	P	07/15/95	06/25/96	6	NA	–2.34	NA
342310103180801	Pa	02/27/04	01/10/05	5	NA	–2.37	NA
342219103183101	Q	11/19/96	08/19/03	17	–2.69	–18.86	0.98
342323103180801	Ra	05/26/04	01/10/05	4	NA	–0.55	NA
342157103181101	S	03/02/99	01/10/05	15	–2.43	–14.56	0.93
342200103180901	T	03/02/99	01/10/05	14	–2.37	–14.19	0.97
342205103181001	U	03/02/99	01/10/05	14	–2.28	–13.68	0.98
342418103201201	V	11/06/03	01/10/05	7	NA	–0.44	NA
342348103175801	W	02/27/04	01/10/05	8	NA	–3.84	NA
342222103194301	X	03/11/04	01/10/05	5	NA	0.14	NA

[1] Periods of record beginning and ending dates differ among wells, which can affect comparison of water-level changes.

Table 9. Change in saturated interval for selected wells at Cannon Air Force Base.

U.S. Geological Survey identification number	Well identifier (fig. 2)	Initial water-level measurement date	Final water-level measurement date	Initial saturated interval[1] (feet)	Final saturated interval (feet)	Overall decrease (feet)	Overall decrease (percent)
342218103182601	A	02/21/94	01/10/05	76.2	49.1	27.1	35.6
342203103181001	B	02/21/94	01/10/05	91.7	59.1	32.6	35.5
342328103182401	E	09/13/94	01/10/05	92.4	75.0	17.4	18.8
342321103181001	F	09/12/94	01/10/05	98.0	80.4	17.6	18.0
342313103180801	G	09/13/94	01/10/05	92.7	74.7	18.0	19.4
342307103181601	H	09/13/93	01/10/05	96.6	77.9	18.7	19.4

[1] Well depth and depth to water from land surface were used to calculate saturated interval.

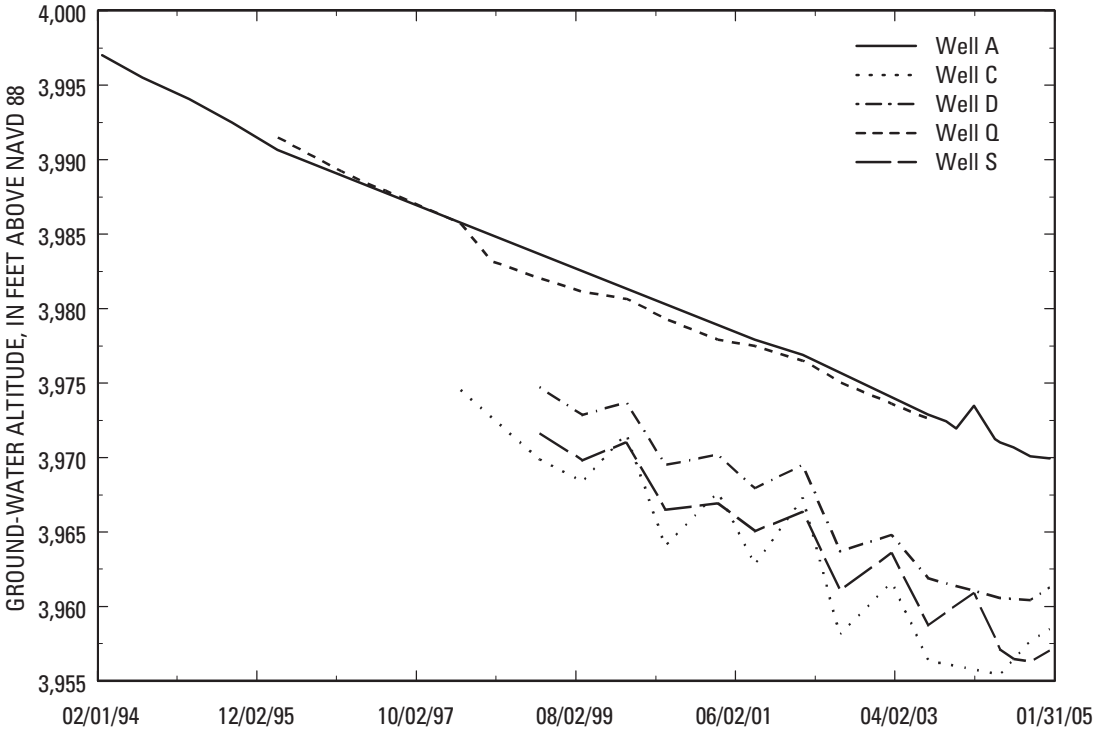

Figure 5. Water-level seasonal fluctuations in selected monitoring wells at Cannon Air Force Base, 1994–2005.

but the water likely is a mixture of this young water and older water that did not contain chlorofluorocarbons (Falk, 2005).

Ground-Water Quality

Water-quality sampling by the USGS at Cannon AFB has been dictated by RCRA and NPDES requirements. Samples collected at the wells were for analysis of specified compounds at each site as required by the State of New Mexico under RCRA and NPDES regulations. Because of this sampling scheme, water-quality data between well groups is not consistent (Sewage Lagoons compared with Landfill 5) and few data are available for interpretation of water composition.

All USGS data are presented as total concentrations from raw (pretreatment) ground-water samples. All SDWA water-quality standards are applicable to posttreatment samples that meet the turbidity requirement of the SDWA. Drinking-water standards are applicable to samples with a turbidity equal to or less than 5 nephelometric turbidity units (NTU) and typically have a turbidity of 1 NTU or less (U.S. Environmental Protection Agency, 2005b). Turbidity values were not collected by the USGS at Cannon AFB. It is possible that the total concentrations at Cannon AFB included a concentration fraction that resulted from suspended material that would not have been present if samples were treated (such as filtering or settling). Comparison of concentrations from pretreatment and posttreatment samples can be misleading, and any total concentrations greater than the standards should be judged with caution.

Anthropogenic Compounds

Analyses for anthropogenic compounds, including organic halogens, volatile organic compounds, semivolatile organic compounds, dioxins, furans, polynuclear aromatic hydrocarbons, organochlorine pesticides, polychlorinated biphenyls, and chlorinated herbicides, have been conducted for samples collected from Landfill 5 and the Sewage Lagoons wells since 1994. The maximum total concentrations of these compounds were small and less than USEPA drinking-water standards (table 10). Anthropogenic compounds that have been detected were pesticide or industrial compounds (table 10), and at least one anthropogenic compound was detected in each monitoring well. Private contractor sampling at wells N, O, Oa, P, Pa, R, and Ra did not detect anthropogenic compounds from 2001 to 2004 (Bhate Environmental Associates, Inc., 2002a, 2002b, 2003a, 2003b, 2004, 2005). Base production-well sampling in 2005 indicated the presence of a small number of pesticide or industrial compounds in wells 3, 4, 7, and 12, at concentrations less than drinking-water standards (C.M. Bohler, U.S. Air Force, written commun., 2005).

The detection of anthropogenic compounds in ground water indicates the presence of modern water (recharged since 1940s) in the Southern High Plains aquifer at Cannon AFB. The presence of these compounds does not indicate recharge at a well site, as the compounds may have traveled from an upgradient location. The number of compounds detected in ground water from well F likely indicates infiltration and

Table 10. Maximum concentrations of anthropogenic compounds detected in ground-water samples collected by the U.S. Geological Survey at Cannon Air Force Base, 1994–2004.

[All concentrations are in micrograms per liter, and all results are total (unfiltered) concentrations; "Use" is the general use of the compound. Compounds may have multiple uses, but a general category of use is presented for differentiating between compounds. The "industrial" use indicates the compound is used for making other compounds or is an additive in other compounds. "---" indicates the compound description is too generic for a determination of general use]

Well identifier (fig. 2)		Landfill 5 wells											Sewage Lagoons wells							Perimeter background wells			
Compound (µg/L)	**Use**	**A**	**B**	**C**	**D**	**I**	**L**	**M**	**Q**	**S**	**T**	**U**	**E**	**F**	**G**	**H**	**N**	**O[1]**	**P[1]**	**V**	**W**	**X**	**Stds[2]**
1,1 Dichloroethene	Industrial			0.22																			7
2-Butanone	Solvent		1.4		1.5								1.0										
2-Hexanone	Industrial														12								
Acetone[3]	Solvent			0.81		37								1.4		1.5							
Aldrin	Pesticide													0.01									
beta-BHC	Pesticide													0.05									
Benzyl alcohol	Industrial																			1.4			
bis(2-ethylhexyl) phthalate[3]	Industrial											9.7											
Boroform	Antiseptic				0.45																		
Carbon disulfide	Industrial									3.7													
Chloroform	Industrial				0.65																		
Chloromethane	Industrial									60													
delta-BHC	Pesticide													0.03									
Dichlorodifluoro-methane	Refrigerant									1.7													
Endosulfan I	Pesticide													0.01									
Endosulfan sulfate	Pesticide													0.02									
Heptachlor	Pesticide													0.02									0.4
Heptachlor epoxide	Pesticide													0.02									0.2
Hexane[3]	Solvent			2.2					1.0				2.5										
Methylene chloride[3]	Solvent	0.25	1.1	1.5	0.45	1.1			0.59	0.31	0.36		2.7	0.43	0.38	5				0.83	0.37	0.34	
Phenolics	Industrial												0.03			0.02							
Tetrachloroethene	Solvent												3.7	0.11									5
Toluene	Gasoline									0.29										0.65	0.17	0.35	1,000
Organic halogens	---		12.9		17		32.3	35.6	6.8	16			8.3										
Trichloroethene	Solvent			1.8	2.4					1.6			0.12		0.18								5
Trichlorofluoro-methane	Refrigerant									0.57													
Xylenes	Gasoline																36	36	13				10,000

[1] Includes samples from wells O and Oa and P and Pa.

[2] Standards: primary drinking-water standards as issued by the U.S. Environmental Protection Agency for National Primary Drinking Water Regulations (U.S. Environmental Protection Agency, 2005b). Standards are for posttreatment samples.

[3] Common sampling/laboratory-associated compounds that have been detected in field-equipment- and method-blank samples on occasion.

movement of treated wastewater from the Sewage Lagoons to the underlying aquifer. The presence of a diverse group of industrial- and agriculture-related compounds may indicate anthropogenic influences from on and off the base. Additionally, some of the contaminants are common sampling/laboratory-associated compounds such as acetone, bis(2-ethylhexyl) phthalate, hexane, and methylene chloride that may have been introduced to the sample during collection or analysis (small concentrations of these compounds have been found in field-equipment- and method-blank samples on occasion).

Perchlorate

The anthropogenic use of perchlorate is as a propellant, but perchlorate has been detected in ground water in northwest Texas where no known anthropogenic source(s) exists (Jackson and others, 2003). Further investigation of perchlorate in northwestern Texas and eastern New Mexico has produced evidence indicating that perchlorate in this area likely is from a natural source and probably is atmospherically deposited (Rajagopalan and others, 2006). Atmospheric processes such as the interaction of chloride and ozone can produce perchlorate naturally (Dasgupta and others, 2005). With wet or dry deposition, perchlorate can accumulate in the soil and subsequently be transported to an aquifer in detectable concentrations. The increasing analytical capability to detect perchlorate at small concentrations has allowed the identification of its likely natural presence in parts of New Mexico (Plummer and others, 2006) and northwest Texas (Rajagopalan and others, 2006).

Perchlorate was detected in at least one sample from every well at Cannon AFB for which perchlorate was analyzed (table 11). The number of perchlorate detections was largest in June 2004 because of the use of a newer analytical method (SW846 8321A; U.S. Environmental Protection Agency, 1986 [revision]) with a lower method detection level than that of the previous method (EPA 314.0; U.S. Environmental Protection Agency, 1999). Using the newer analytical method, concentrations of perchlorate in ground water at Cannon AFB ranged from 0.21 to 5.6 µg/L. These concentrations are similar to perchlorate concentrations detected in eastern New Mexico and northwest Texas by Rajagopalan and others (2006) that were largely attributed to a natural, atmospheric source. The wide distribution of perchlorate at small concentrations at Cannon AFB also appears to indicate a natural, atmospheric source. The variation in perchlorate concentrations between ground-water samples from the various wells may be related to recharge and flow paths in the aquifer.

Regulation of perchlorate (contaminant candidate) is being considered by the USEPA under the SDWA. The USEPA has not set a maximum contaminant level for perchlorate, but California has set a public health goal of 6 ppb for dissolved concentrations (Council on Water Quality, 2005). Other States have set advisory levels for drinking water, and the USEPA has established an official reference dose of 0.0007 mg/kg/day of perchlorate that translates to a drinking-water equivalent level of 24.5 ppb (U.S. Environmental Protection Agency, 2005a). Only perchlorate concentrations in samples from well T (estimated values because of chloride interference) were greater than California's public health goal, and these results occurred when the previous, less accurate analytical method was used (table 11). Perchlorate concentrations in samples from well T using the newer analytical method resulted in concentrations smaller than California's public health goal (assuming equivalent units).

Trace Elements

Total trace-element concentrations in raw ground water at Cannon AFB generally were less than USEPA primary and secondary drinking-water standards (U.S. Environmental Protection Agency, 2005b). Maximum total concentrations of aluminum, iron, and manganese exceeded secondary drinking-water standards, and maximum chromium concentrations exceeded the primary drinking-water standard (fig. 6). It is possible that trace-element concentrations in raw (pretreatment and unfiltered) samples collected at Cannon AFB included a concentration fraction that resulted from suspended material. Comparison of concentrations from pretreatment and posttreatment samples can be misleading, and any total concentrations greater than the standards should be judged with caution.

At least one sample exceeded the aluminum secondary drinking-water standard of 50 µg/L for every well at Cannon AFB for which ground water was analyzed for aluminum (fig. 7). In ground water from wells B, D, F, H, I, L, M, and Q, at least one iron concentration exceeded the secondary drinking-water standard of 300 µg/L (fig. 8). Water-quality data from contractor sampling indicate that ground water from wells N, O, Oa, R, and Ra (Sewage Lagoons) also have exceeded the 300-µg/L secondary standard for iron (Parallax, Inc., 2000; Bhate Environmental Associates, Inc., 2002a, 2002b, 2004, and 2005). One manganese concentration exceeded the secondary drinking-water standard of 50 µg/L in ground water collected from wells H and Q (fig. 9). One sample from well Ra (not shown in fig. 9, contractor data not compiled with USGS data) sampled by a private contractor also exceeded the secondary drinking-water standard for manganese (Bhate Environmental Associates, Inc., 2002b). In ground water from wells L and M (Landfill 5), one chromium concentration exceeded the primary drinking-water standard of 100 µg/L (fig. 10). Ground water collected from production wells in 2002 by a contractor contained small concentrations of arsenic, barium, chromium, nickel, and selenium that were smaller than drinking-water standards (Earth Tech, Inc., 2005).

Nitrate and Organic Carbon

Results of total nitrate (nitrate plus nitrite or nitrate) analysis indicate that only ground water from wells G and P (Sewage Lagoons) exceeded the posttreatment USEPA (2005b) primary drinking-water standard of 10 mg/L (fig. 11). These larger concentrations were likely a result of infiltrated

Table 11. Perchlorate concentrations in ground water at Cannon Air Force Base.

[MDL, method detection level; RL, reporting level; E, estimated; all concentrations in micrograms per liter and all results are total concentrations]

Well identifier (fig. 2)	Mar 2001	Aug 2002	Mar 2003	Aug 2003	June 2004
	MDL= 5, RL = 20		*MDL= 0.2, RL =1*		*MDL = 0.0012, RL = 0.01*
A					2.4
B		5.0 E	2.1	2.4	2.3
C					0.41
D					0.21
E			1.7		1.8
F			2.3		2.2
G			1.7		1.7
H			2.4		2.6
Q	5.8 E		2.2		
S		4.6 E	2.4	2.9	2.7
T	19.9 E	6.5 E	2.3	2.7	2.3
U			2.3	2.4	2.3
V					5.6
W					0.63
X					1.1

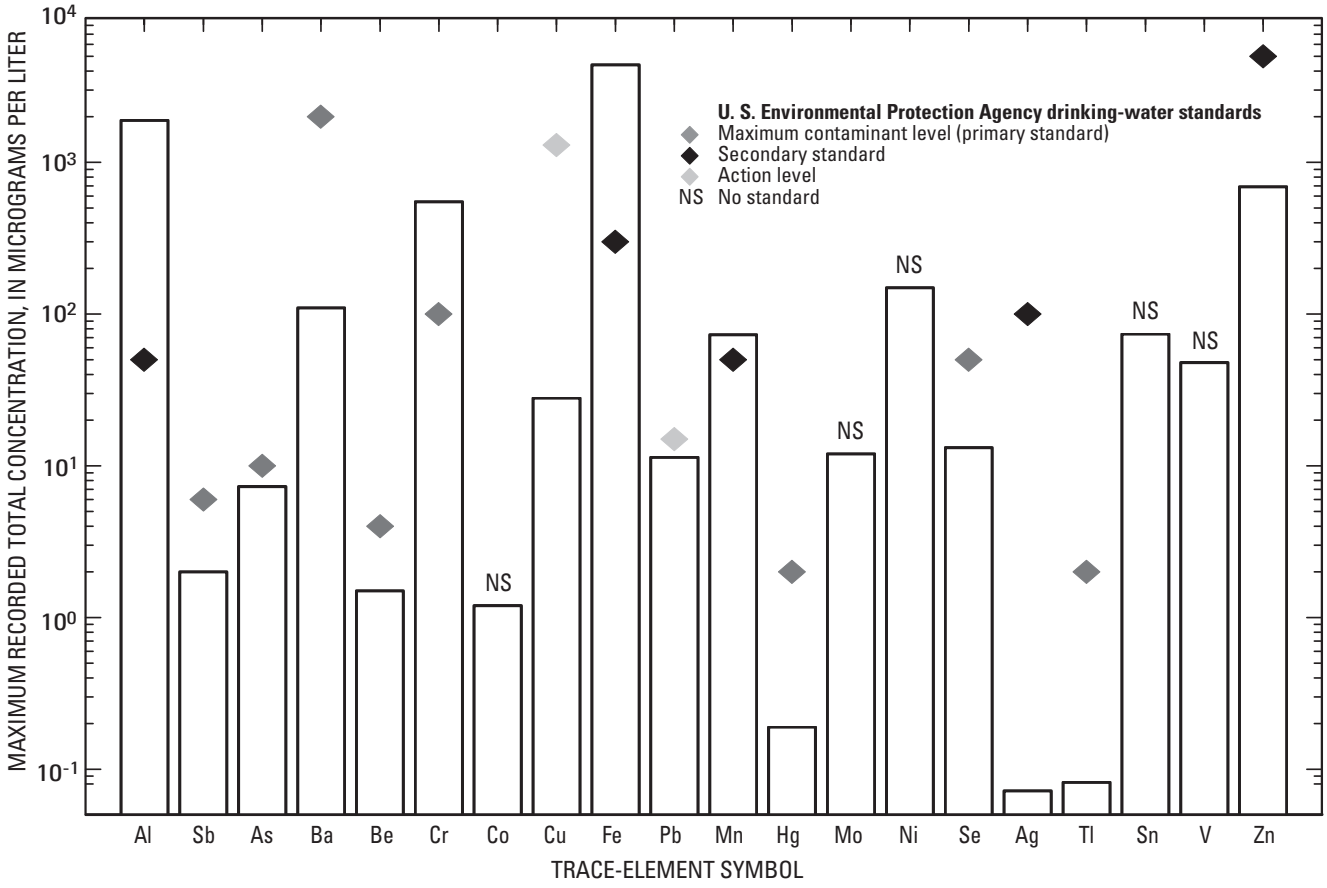

Figure 6. Maximum recorded total trace-element concentrations in ground water at Cannon Air Force Base, 1994–2004, and U.S. Environmental Protection Agency (2005b) drinking-water standards.

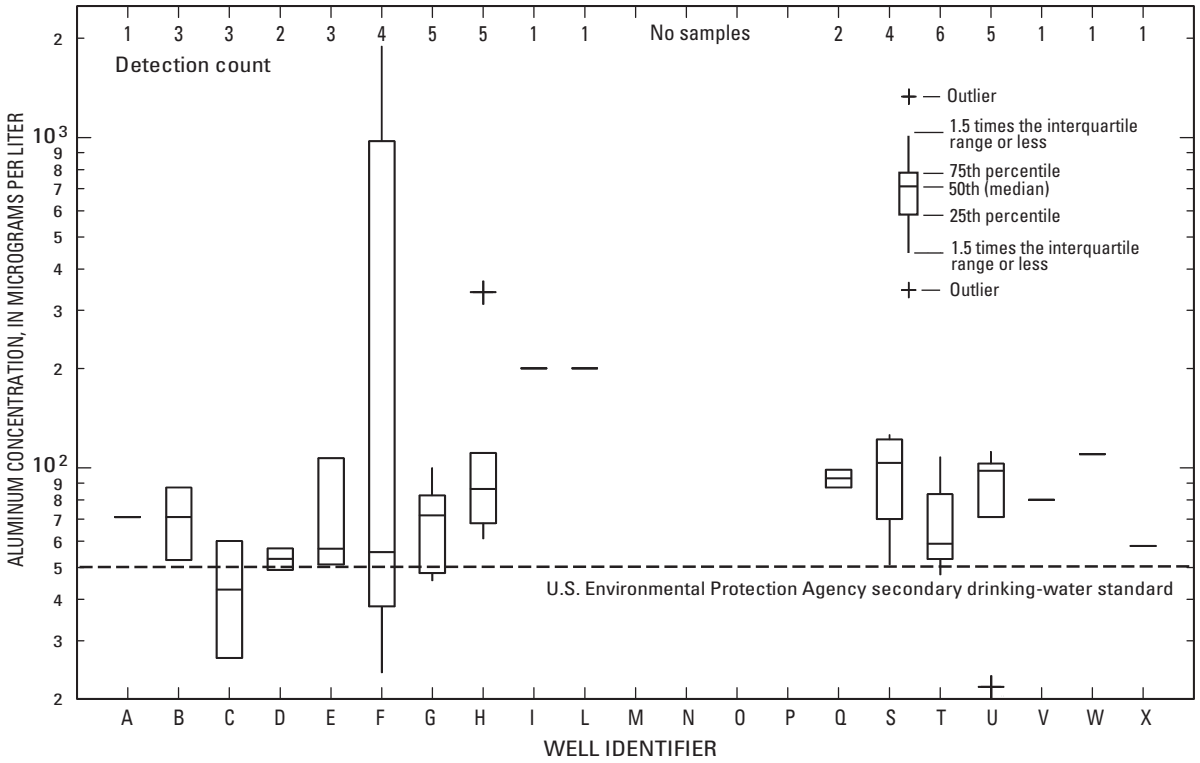

Figure 7. Aluminum concentrations in ground water at Cannon Air Force Base, 1994–2004.

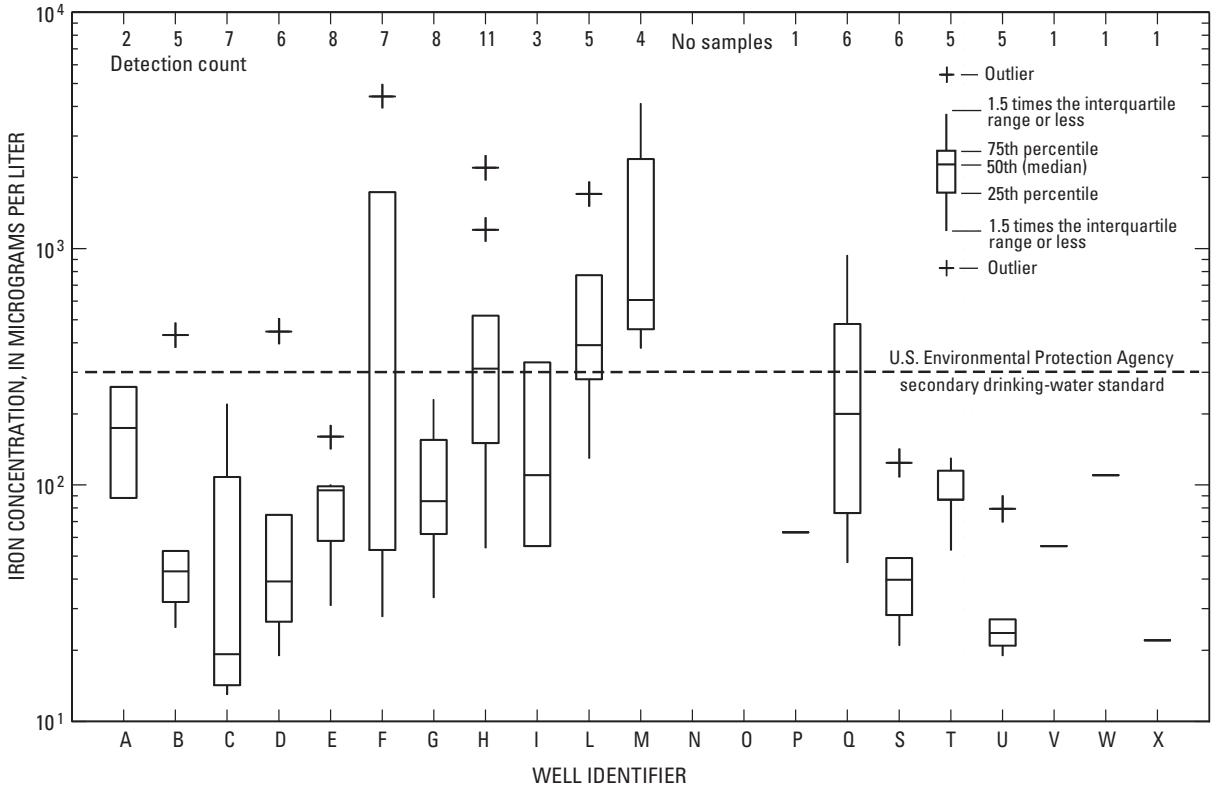

Figure 8. Iron concentrations in ground water at Cannon Air Force Base, 1994–2004.

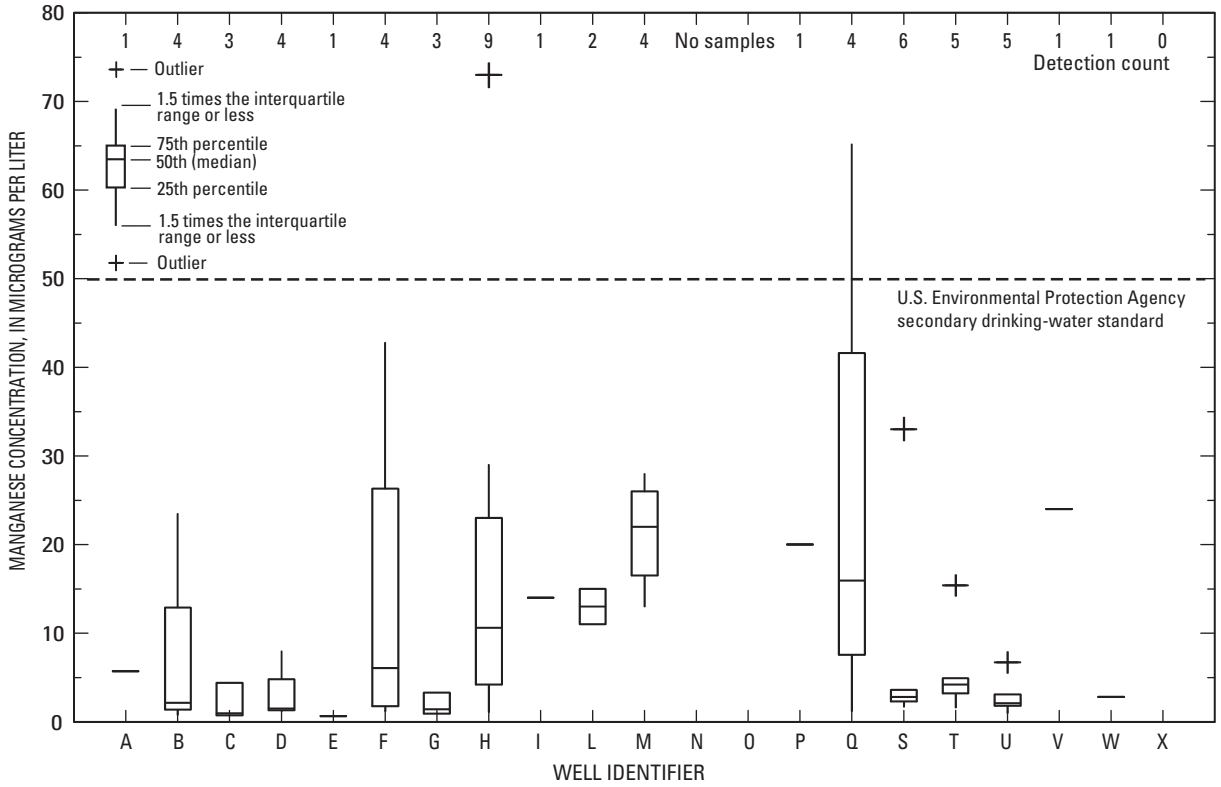

Figure 9. Manganese concentrations in ground water at Cannon Air Force Base, 1994–2004.

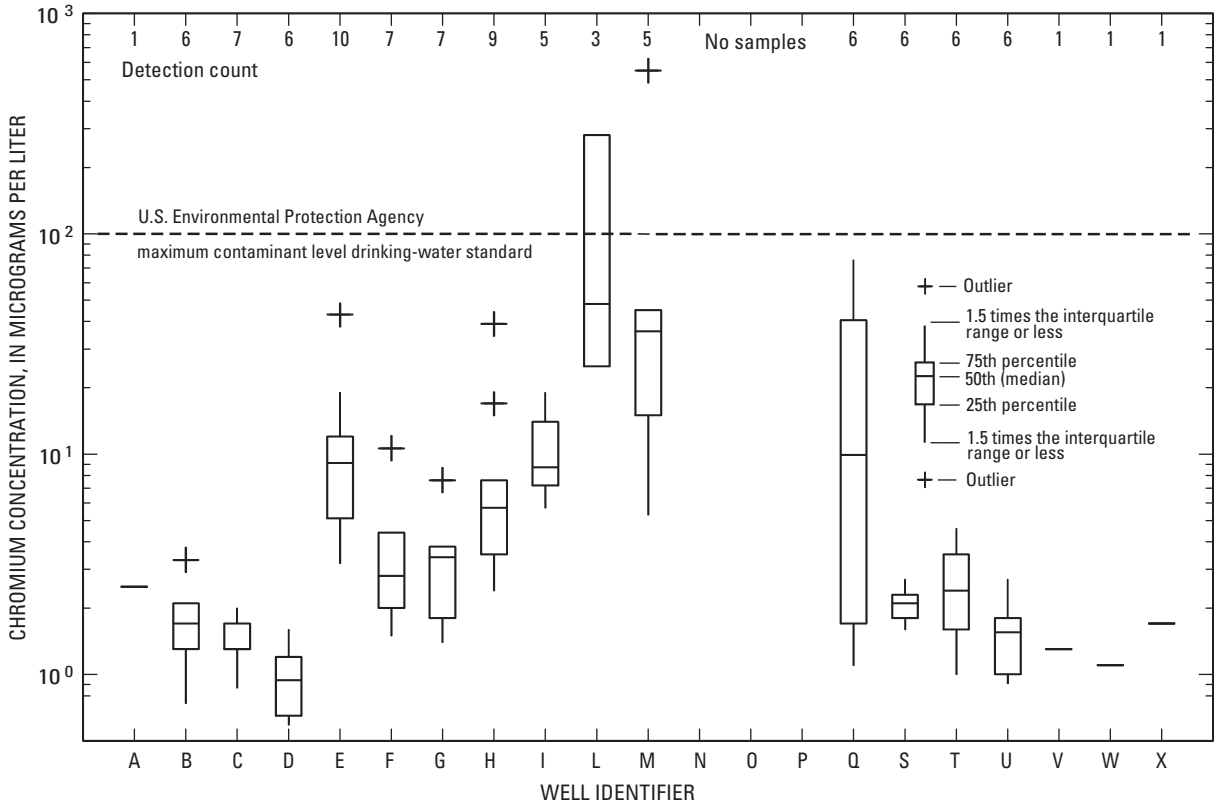

Figure 10. Chromium concentrations in ground water at Cannon Air Force Base, 1994–2004.

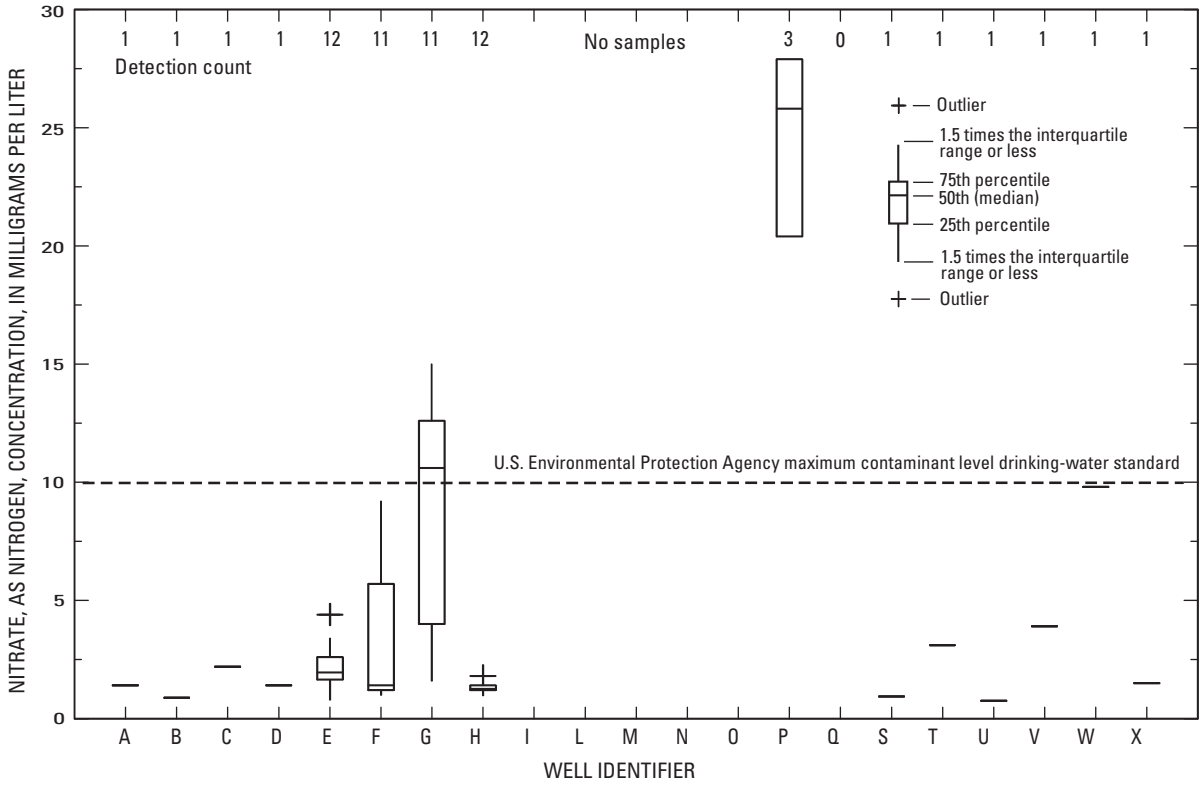

Figure 11. Total nitrate, as nitrogen, concentrations in ground water at Cannon Air Force Base, 1994–2004.

treated wastewater. Data for wells near the Sewage Lagoons (E-H) have a sufficient temporal scale to observe the influence and decline of nitrate concentrations due to infiltrated wastewater. From 1994 to 2004, nitrate concentrations in ground water near the Sewage Lagoons decreased before and after decommissioning (lagoons were decommissioned in 1998, but inflow was reduced and halted before this date) to concentrations in wells not affected by the lagoons (fig. 12).

Concentrations of total organic carbon (TOC) were generally near or less than 1 mg/L in ground water at Cannon AFB (fig. 13). One detection of TOC in ground water from well F in 2004 was at a concentration of 9.5 mg/L. Ground water from well F did not previously contain a detectable concentration of TOC, and the reason for the large TOC concentration is unknown. Ground water collected in 2005 from production wells at the base either contained no detectable TOC or a concentration less than 1 mg/L (C.M. Bohler, U.S. Air Force, written commun., 2005).

Major Ions

Alkalinity or carbonate species concentrations have not been analyzed as part of USGS water-quality sampling at Cannon AFB, but a full set of major-ion concentrations for ground water at wells D, E, V, W, and X (fig. 2) was recorded as part of a recharge investigation conducted by the USGS at the base in 2004 (Falk, 2005). Different water compositions were present in different parts of the base, and chloride concentrations varied substantially (fig. 14). Samples from wells E, V, and W were a calcium/magnesium-sulfate water type (per Back's [1961] classification diagram), and samples from wells D and X were a calcium/magnesium-bicarbonate water type.

Calcium and sulfate were analyzed for samples collected in June 2004 from most of the wells at Cannon AFB. Differences in the ratio of these ions in ground water (fig. 15) may be indicative of multiple source waters with different recharge areas or leakage of water from the Chinle Formation into the Ogallala Formation, although such differences could be from an anthropogenic source(s). Calcium and sulfate concentrations from June 2004 illustrate some linearity indicating the possible mixing of different source waters represented by ground water from wells V and X. Wells D, E, and W do not conform to this scenario, and calcium concentration varies substantially among the middle grouping of wells (fig. 15).

Examination of major cation to sulfate ratios for the June 2004 data provides further indication of multiple source waters or other influences on ground water in the Southern High Plains aquifer at Cannon AFB. Similar cation/sulfate ratios indicating similar source waters were present for samples from nearly all wells, except for samples from wells C, D, E, and X (fig. 16). Wells C, D, and X are located along the southern boundary of Cannon AFB, but wells A, S, T, and U are also located in this area and water from these wells did not contain the larger cation/sulfate ratios that are apparent for wells C, D, and X. Samples from wells A, S, T, and U did indicate variable concentrations of calcium and sulfate (fig. 15). A difference in

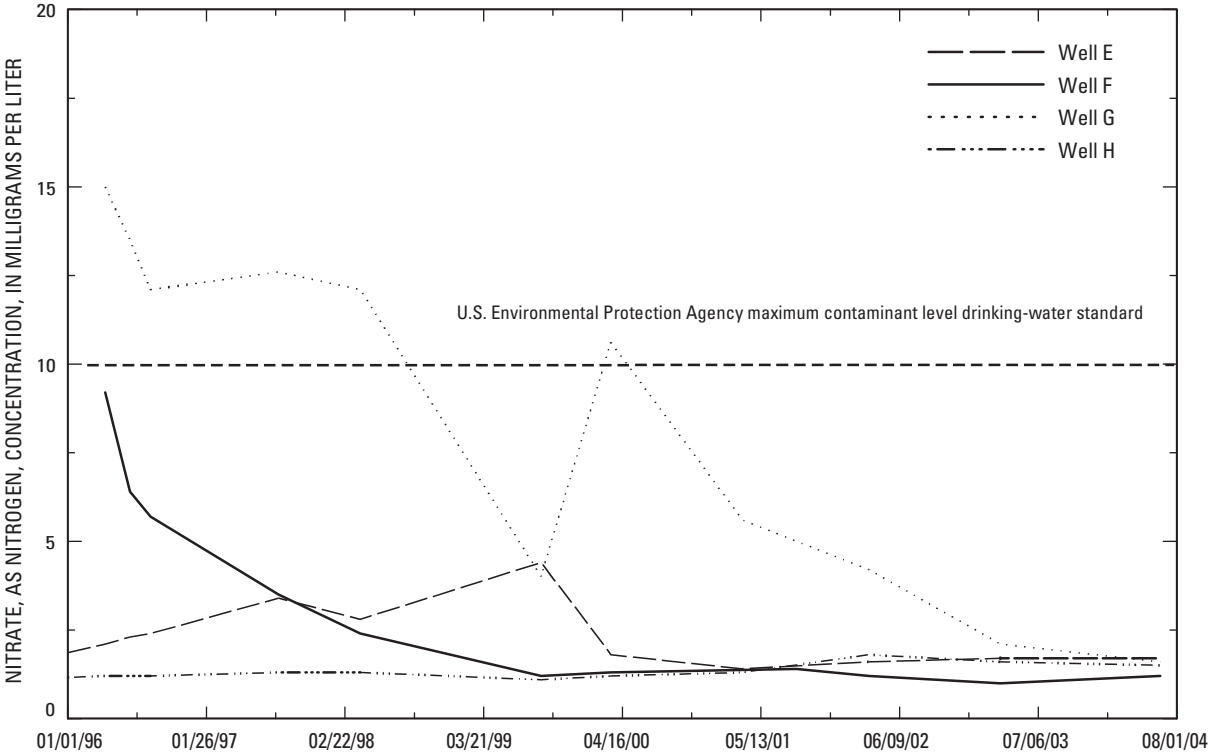

Figure 12. Total nitrate, as nitrogen, concentrations in ground water from wells near the Sewage Lagoons at Cannon Air Force Base, 1996–2004

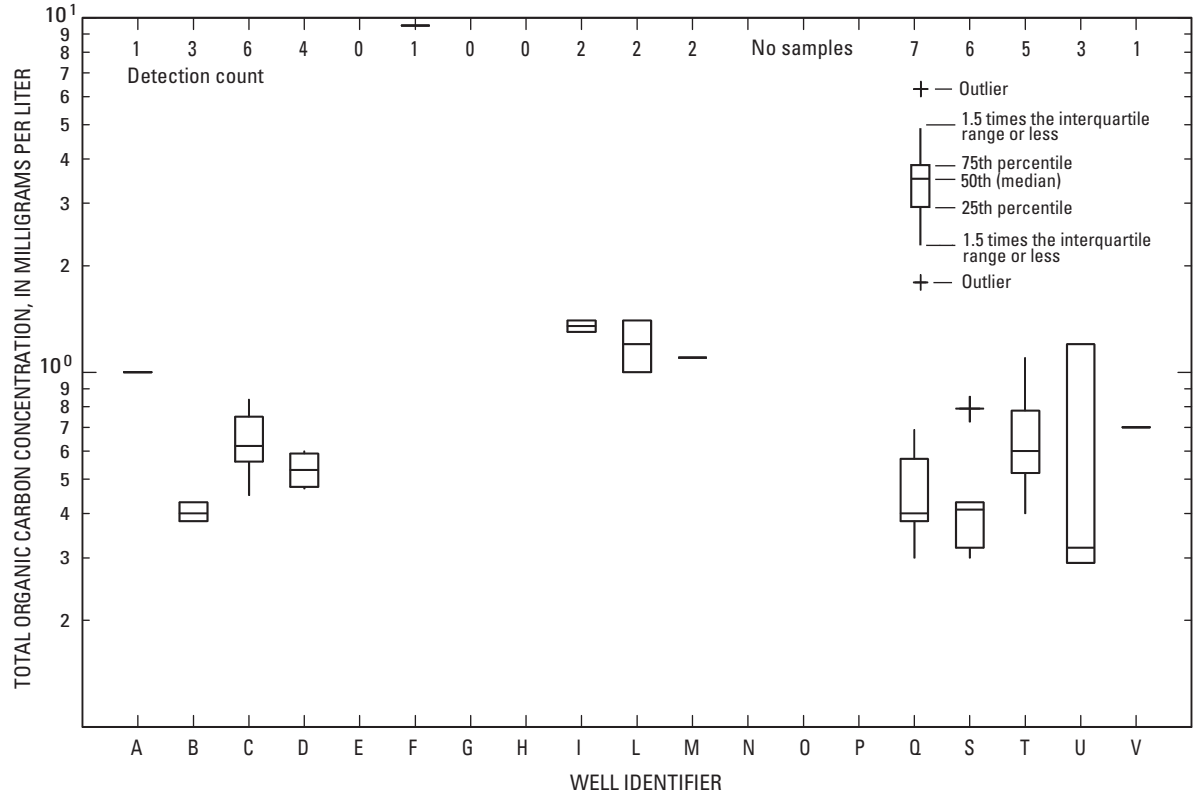

Figure 13. Total organic carbon concentrations in ground water at Cannon Air Force Base, 1994–2004

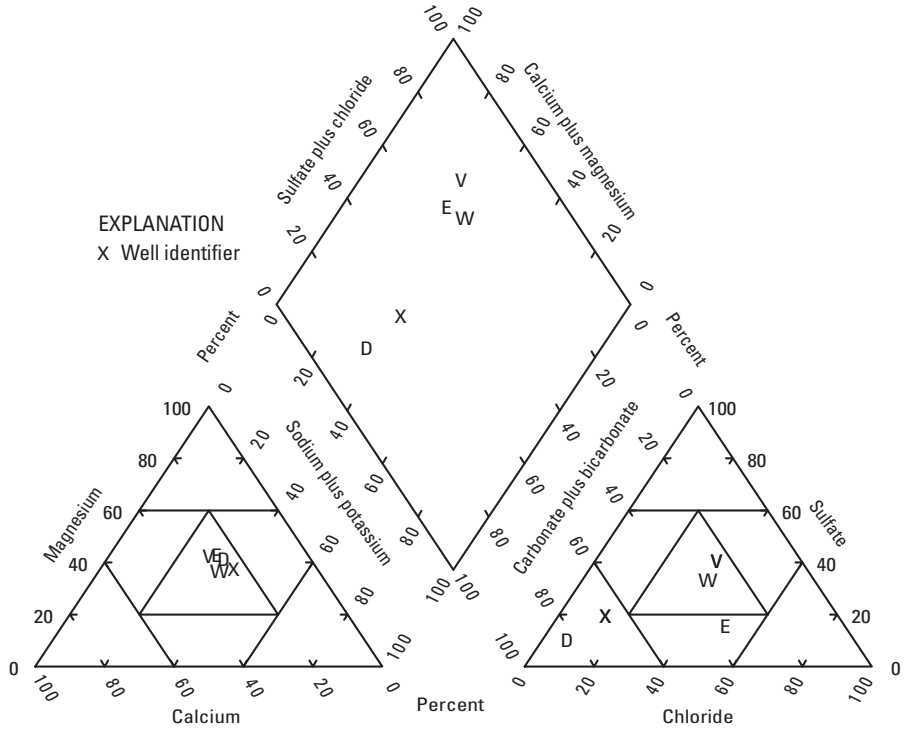

Figure 14. Piper diagram of major-ion composition in ground water from selected wells at Cannon Air Force Base, July 2004.

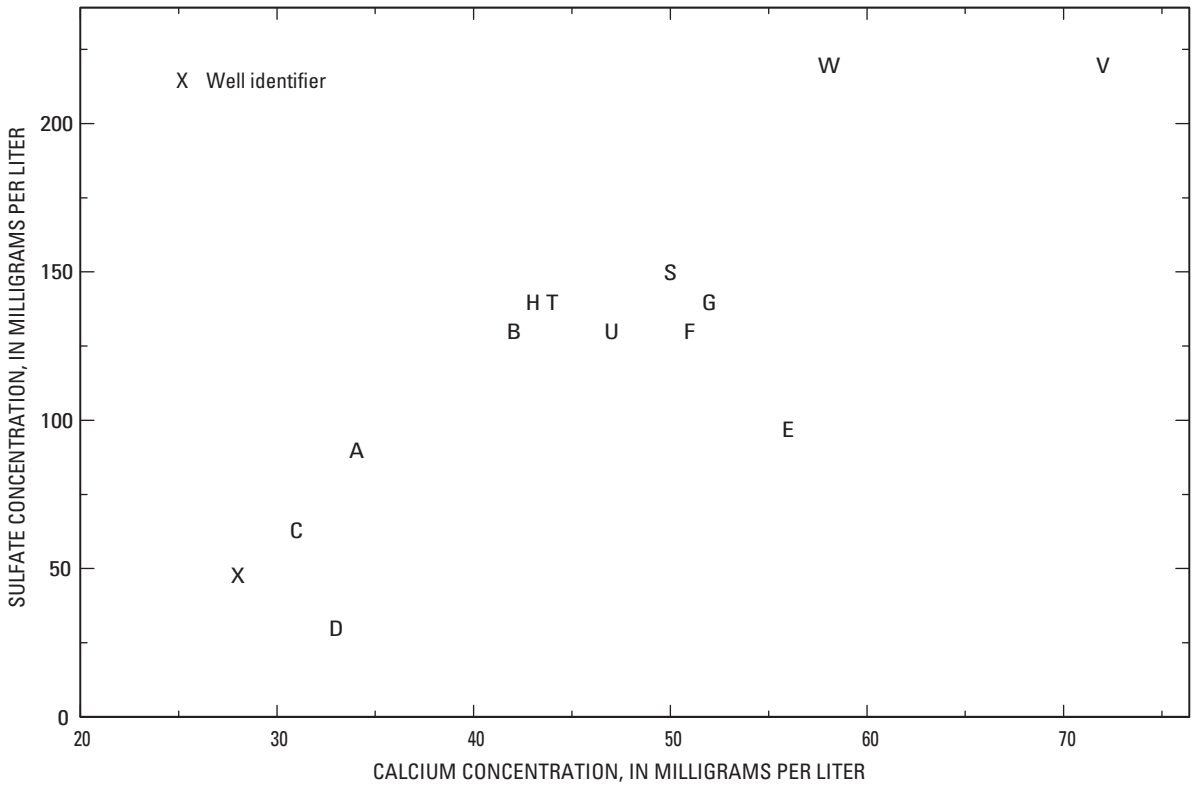

Figure 15. Calcium and sulfate concentrations in ground water at Cannon Air Force Base, June 2004.

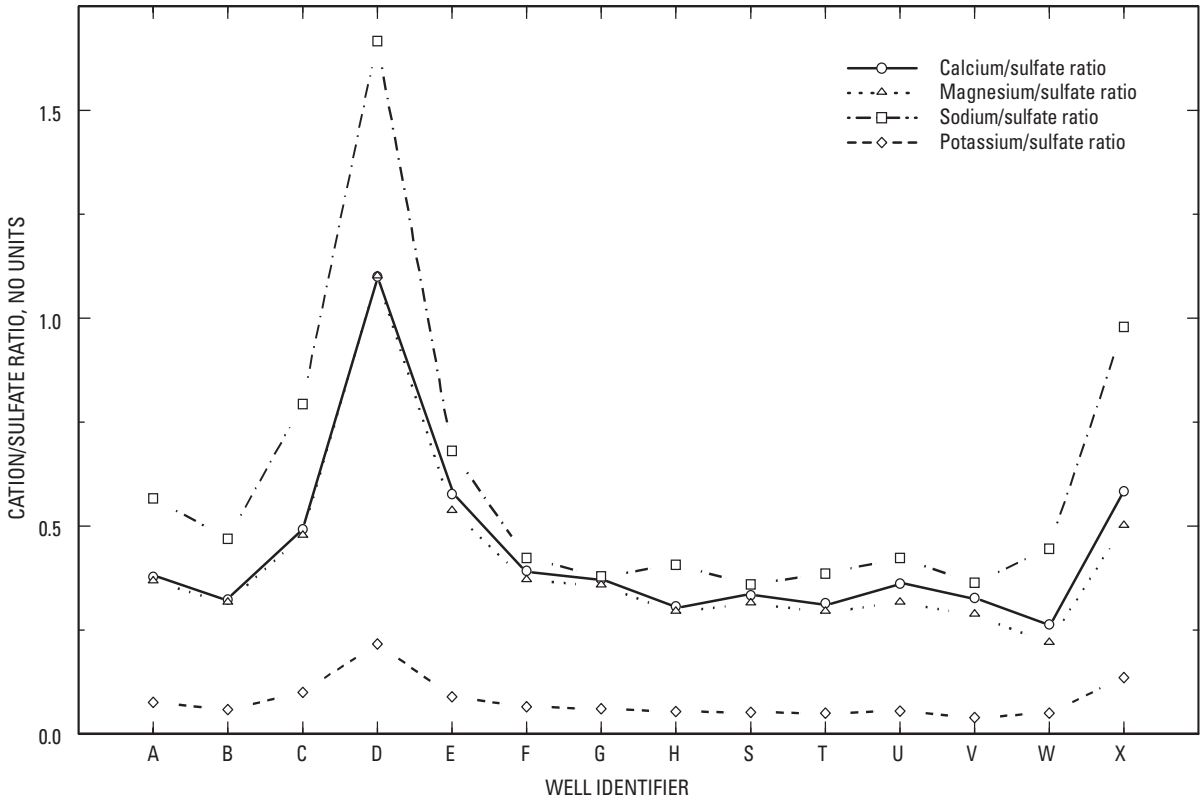

Figure 16. Cation and sulfate ratios for ground water at Cannon Air Force Base, June 2004.

ion ratios can suggest different rock/water interactions for the possible source waters.

Because the influence of Sewage Lagoons appears to have lessened by 2004 (fig. 12) and the largest concentrations of calcium and sulfate in 2004 were detected in wells upgradient from the Sewage Lagoons (background wells V and W), the Southern High Plains aquifer at Cannon AFB likely is a mixture of multiple source waters. Ground water of different ages and composition was evident from USGS sampling at Melrose Air Force Range for the Southern High Plains aquifer (Langman and others, 2004). Age dating of ground water at Cannon AFB by the USGS (Falk, 2005) produced a range of ages (25 to 50 years) and indicated mixing of source waters. It is possible that source waters from different formations or recharge areas are mixing in the Cannon AFB area, but the water-quality data set from USGS monitoring at Landfill 5 and the Sewage Lagoons is insufficient to support this conclusion.

General Physical and Chemical Properties

The general physical and chemical properties (specific conductance, temperature, and pH) of ground water at Cannon AFB provide an overview of spatial and temporal differences in water quality. Specific conductance is a particularly useful parameter because it indicates the amount of dissolved ions in the water. The large range and large values of specific conductance in water from wells E, F, G, and P (fig. 17) likely were a result of infiltrating water from the Sewage Lagoons (fig. 2). Although well E is upgradient from the Sewage Lagoons, infiltrating water from the lagoons likely spread in all directions in the approximately 300-ft-thick vadose zone and affected water quality in an area surrounding the lagoons. Human use of water typically increases the mineral content, which results in treated wastewater with larger specific conductance than the source water (Tchobanoglous, 1991). Additionally, evaporation of treated wastewater in the lagoons would further increase specific conductance of water that would infiltrate and mix with the underlying aquifer.

The specific conductance of ground water in wells outside the influence of the Sewage Lagoons (wells I, L, M, Q, S, T, U, V, W, and X) also indicated differences in water quality and may indicate the mixing of source waters in the Southern High Plains aquifer at Cannon AFB (fig. 17). This spatial difference in specific conductance in the Southern High Plains aquifer was observed at Melrose Air Force Range (25 mi west of Cannon AFB) (fig. 1) and was attributed to upward flow of larger conductance water from the Chinle Formation into the Ogallala Formation (Langman and others, 2004). Identifying cross-formational flow at Cannon AFB is complicated by possible anthropogenic influences and (or) multiple recharge source waters and cannot be determined from the Landfill 5 and Sewage Lagoons data sets.

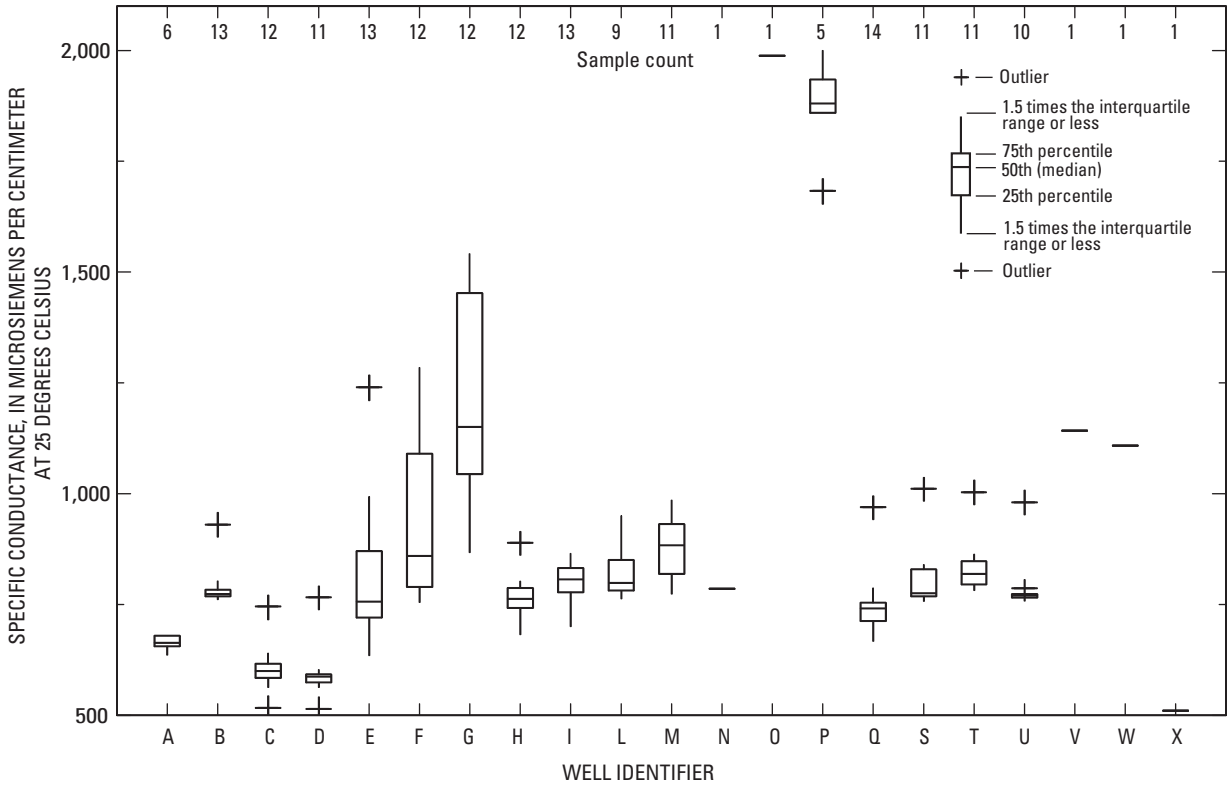

Figure 17. Ground-water specific conductance at Cannon Air Force Base, 1994–2004.

The specific conductance in water from the wells near the Sewage Lagoons decreased from 1994 to 1998 because of the declining influence of infiltrating wastewater as the lagoons were decommissioned and finally closed in 1998 (fig. 18). Infiltrating wastewater from the lagoons appears to have substantially influenced the water quality in wells closest to the lagoons and in the direction of ground-water flow (northwest to southeast). Two years after the final closure of the lagoons, specific conductance in ground water from wells E, F, and H steadily began to increase. The source of this increase is unknown but may be related to the possibility of multiple source waters for the aquifer at Cannon AFB.

Ground water in wells near Landfill 5 indicates possible multiple source waters or anthropogenic influences (fig. 19). Specific conductance of ground water in wells along the southern boundary of the landfill (wells C and D) were smaller than values for ground water in wells along the eastern boundary (B, S, T, and U). Landfill 5 does not appear to be the source or only source causing this difference because the specific conductance of ground water in well A (background well for Landfill 5 sampling) was typically larger than values for wells C and D, although values for well A were typically smaller than values for wells B, S, T, and U (fig. 17). The increasing specific conductance in ground water near the Sewage Lagoons after decommissioning of the lagoons is not apparent with ground water near Landfill 5.

The majority of recorded ground-water temperatures at Cannon AFB were between 16 and 20ºC (fig. 20). The largest ground-water temperatures were at wells I, L, and M, located in the southeastern corner of the base near Landfill 5. These wells were completed at shallower depths compared to most of the remaining wells (table 1), and these wells no longer contain water because of declining water levels. Ground water in these wells indicated seasonal fluctuations in temperature, which could be attributed to seasonal recharge.

Ground-water pH at Cannon AFB was slightly alkaline; most values were larger than 7.0, and all median pH values were between 7.0 and 8.0 (fig. 21). The smallest median pH value was for ground water at well M, and the largest median value was for ground water at well U. Ground water from wells near Landfill 5 indicated the largest variations in pH.

Summary

In cooperation with the U.S. Air Force, the U.S. Geological Survey has collected hydrologic data about the Southern High Plains aquifer at Cannon Air Force Base in east-central New Mexico since 1994. This report summarizes and interprets available hydrologic data collected by the USGS at Cannon AFB from 1994 to 2005. Under the direction of Cannon AFB, the USGS collected hydrologic data at regulated sites of

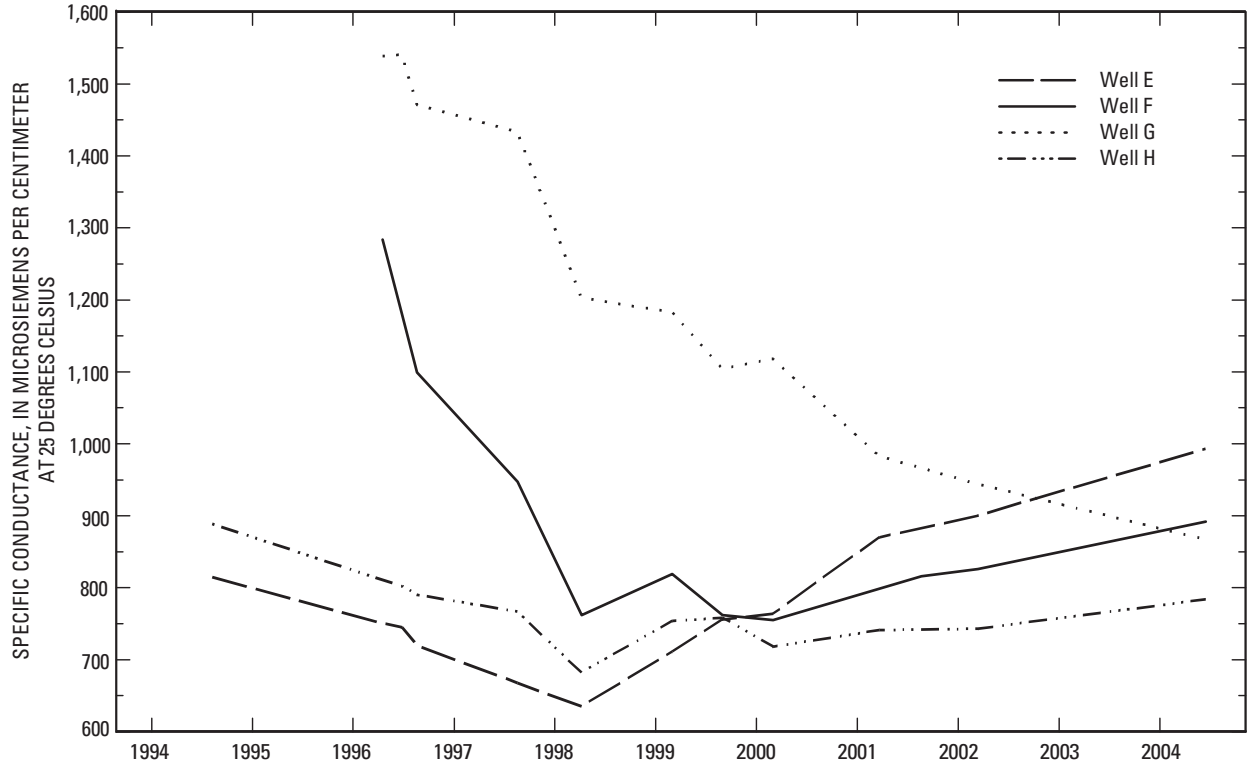

Figure 18. Ground-water specific conductance near the Sewage Lagoons at Cannon Air Force Base, 1994–2004.

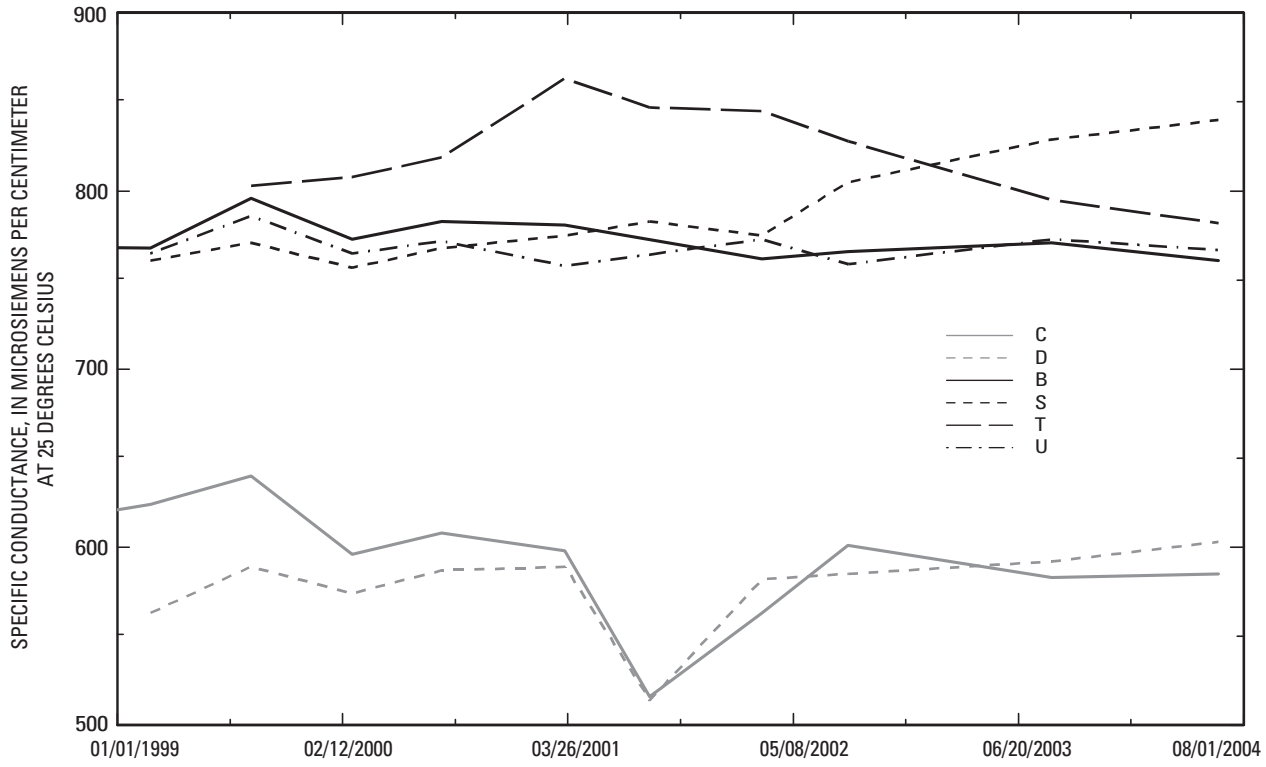

Figure 19. Ground-water specific conductance near Landfill 5 at Cannon Air Force Base, 1999–2004.

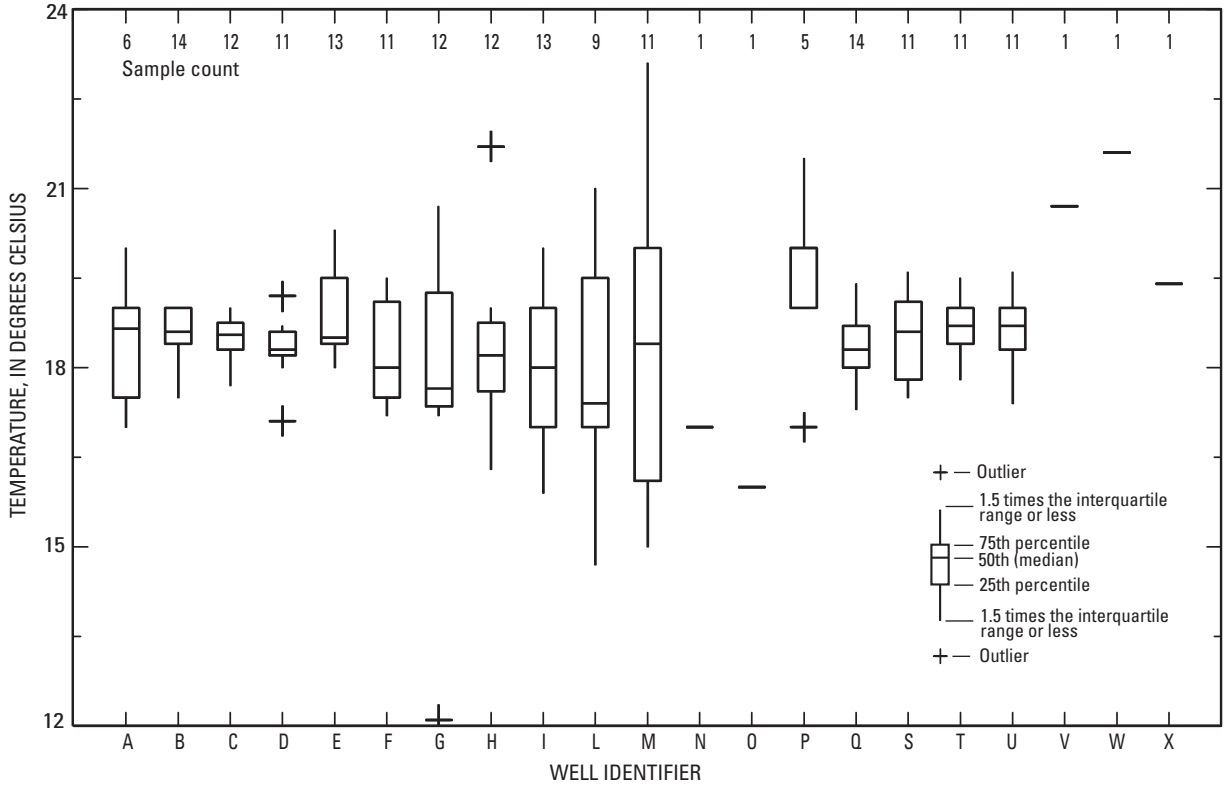

Figure 20. Ground-water temperatures at Cannon Air Force Base, 1994–2004.

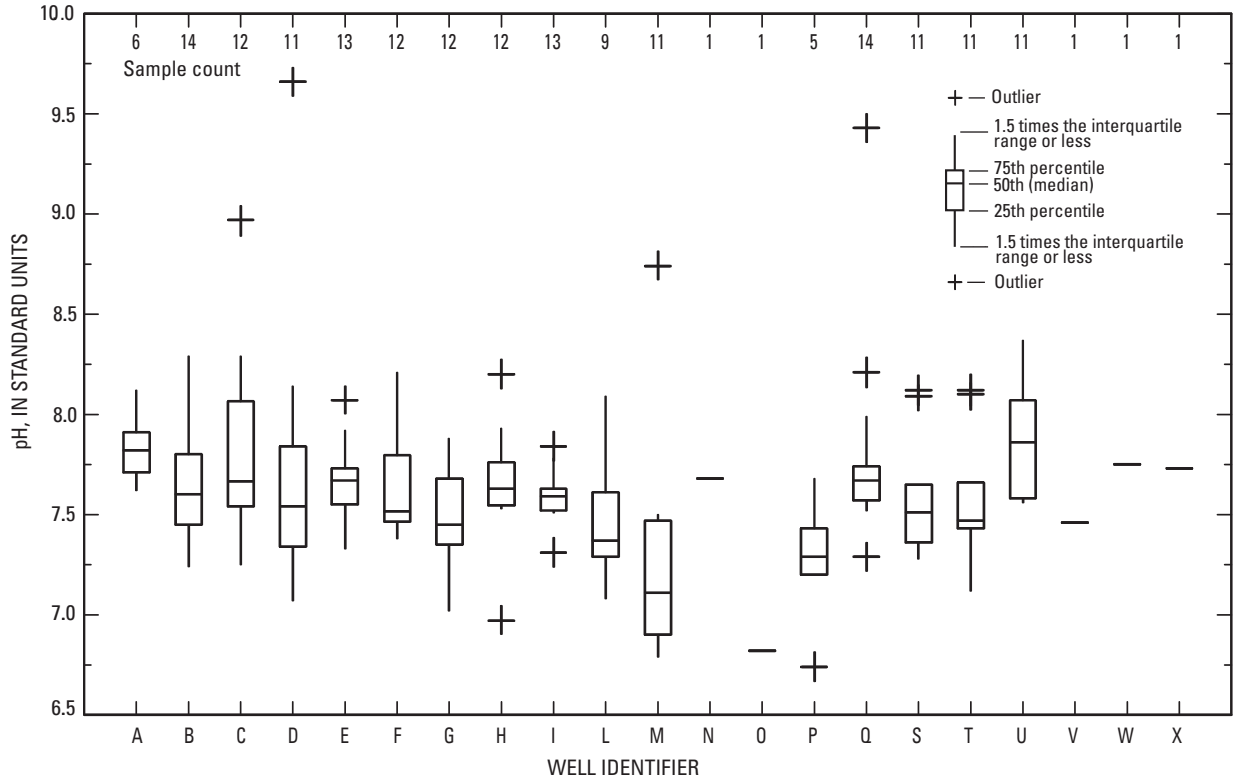

Figure 21. Ground-water pH at Cannon Air Force Base, 1994–2004.

Landfill 5 and the Sewage Lagoons as required by the State of New Mexico. The interpretation of data collected at these sites provides a characterization of the Southern High Plains aquifer that Cannon AFB environmental managers can use for future planning efforts to protect the aquifer and ensure continued operation of all current (2006) activities. Data were compiled from all monitoring wells used from 1994 to 2005 for compliance with RCRA regulations applicable to the Landfill 5 site and the NPDES regulations applicable to the Sewage Lagoons site. Ground-water altitude data also were compiled from an additional 120 wells in a 3-mi radius of Cannon AFB to examine the hydrologic properties of the aquifer at Cannon AFB in relation to the regional aquifer properties.

Cannon AFB is located in the Southern High Plains physiographic region, and saturated deposits of the Ogallala Formation at Cannon AFB are within the western boundary of the Southern High Plains aquifer. The general direction of ground-water flow in the Cannon AFB area is from northwest to southeast. In 1962, ground water in the Southern High Plains aquifer predominantly flowed northwest to southeast with minimal change in direction. Ground-water altitudes declined from 1962 to 1997, and a pronounced water-level recession (area of receding water level) developed northwest of Cannon AFB, altering flow direction in this area. The recession northwest of the base and the subsequent change in direction of ground-water flow are indicative of local ground-water withdrawals upgradient from Cannon AFB.

Ground-water levels have declined substantially throughout the Southern High Plains aquifer since the mid-1940s when ground water was first used for irrigated agriculture. Historical water levels in wells within a 3-mi radius of Cannon AFB declined in 52 of 56 wells for various periods of record between 1962 and 2004, 43 of 56 wells indicated strong linear decreases with time, and the largest decline was 91.80 ft, an average annual decline of about 2.13 ft per year. Water levels in wells at Cannon AFB reflected the regional decline; water levels declined for all wells with periods of record greater than 1 year, and the decline was strongly linear. Wells with the longest records of water-level measurements exhibited minor periods of recovery but a dominant decline in water levels during the past 50 years. These declining regional water-level data likely indicate ground-water withdrawals from the resource that exceeded recharge.

From 1994 to 2005, rates of declining water levels at the base ranged from 1.45 to 1.64 ft per year near the Sewage Lagoons and from 2.24 to 4.01 ft per year near Landfill 5. The difference in rates of decline for ground water at the Sewage Lagoons and Landfill 5 was likely a result of local recharge to the aquifer near the Sewage Lagoons from infiltration of treated wastewater from the previously used lagoons and the current disposal area (Playa Lake). The largest variation in water levels at Cannon AFB was observed in wells C, D, and S, which are located near Landfill 5 along the southern boundary of the base and near an irrigation well immediately south of the base boundary. Water levels in C, D, and S indicated a pattern of summer water-level decline followed by partial winter water-level recovery, which was likely a result of drawdown and recovery during the irrigation and nonirrigation seasons. This water-level pattern, however, was scarcely apparent or was absent in wells A and Q, which are about 0.4 mi north-northwest of the irrigation well.

Ground-water sampling by the USGS from 1994 to 2004 at monitoring wells associated with Landfill 5 and the Sewage Lagoons indicated temporal and spatial differences in water quality. At least one anthropogenic compound was detected in ground water from each monitoring well surrounding Landfill 5 and the Sewage Lagoons. All compounds detected were either pesticide or industrial compounds, and all concentrations were less than USEPA drinking-water standards. Perchlorate was detected in at least one sample from every well for which perchlorate was analyzed, but the source of perchlorate is likely natural and probably a result of atmospheric deposition. Trace-element concentrations in raw ground water at Cannon AFB were generally less than USEPA drinking-water standards. Maximum concentrations of aluminum, iron, and manganese exceeded secondary drinking-water standards, and maximum chromium concentrations exceeded the primary drinking-water standard. Results of nitrate plus nitrite analysis indicate that only samples from wells G and P exceeded the drinking-water standard of 10 mg/L.

Larger concentrations of nitrate in ground water at wells G and P were likely a result of infiltrated treated wastewater. From 1994 to 2004, during which the Sewage Lagoons were decommissioned, nitrate concentrations in wells near the Sewage Lagoons decreased to levels found in wells not affected by infiltrating wastewater. Concentrations of TOC were generally near or less than 1 mg/L in ground water at the base. One detection of TOC in ground water at well F in 2004 was at a concentration of 9.5 mg/L. Ground water from well F previously did not contain a detectable concentration of TOC. The reason for such a large increase in TOC concentration in ground water from well F is unknown.

The spatial and temporal variation of major ions and specific conductance of ground water at Cannon AFB indicates various natural and (or) anthropogenic influences on ground water. Calcium and sulfate concentrations were widely variable in ground-water samples collected in 2004 from wells across the base. Similar cation/sulfate ratios were present for samples from nearly all wells, except for samples from certain wells along the southern boundary of the base and the background well for the Sewage Lagoon monitoring. Differences in major-ion concentrations and ratios and specific conductance across the base were likely the result of different source waters that form the Southern High Plains aquifer.

The decreasing specific conductance from 1994 to 1998 in water from wells near the Sewage Lagoons is explained by the decreasing influence of infiltrating wastewater as the lagoons were decommissioned. Infiltrating wastewater from

the lagoons appears to have substantially influenced the water quality in wells closest to the lagoons and in the direction of ground-water flow (northwest to southeast). Two years after the decommissioning of the lagoons, specific conductance in ground water from wells E, F, and H began to increase steadily. The source of this increase is unknown but may be related to the possibility of multiple source waters for the Southern High Plains aquifer at Cannon AFB. The increasing specific conductance in ground water near the Sewage Lagoons after decommissioning of the lagoons was not apparent with ground water near Landfill 5.

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Supplemental Information

Figure I–1. Location of selected wells at Cannon Air Force Base and the surrounding area.

Table I–1. Information for selected wells at Cannon Air Force Base and the surrounding area.

Table I–2. Altitudes of water levels in selected wells at Cannon Air Force Base and the surrounding area.

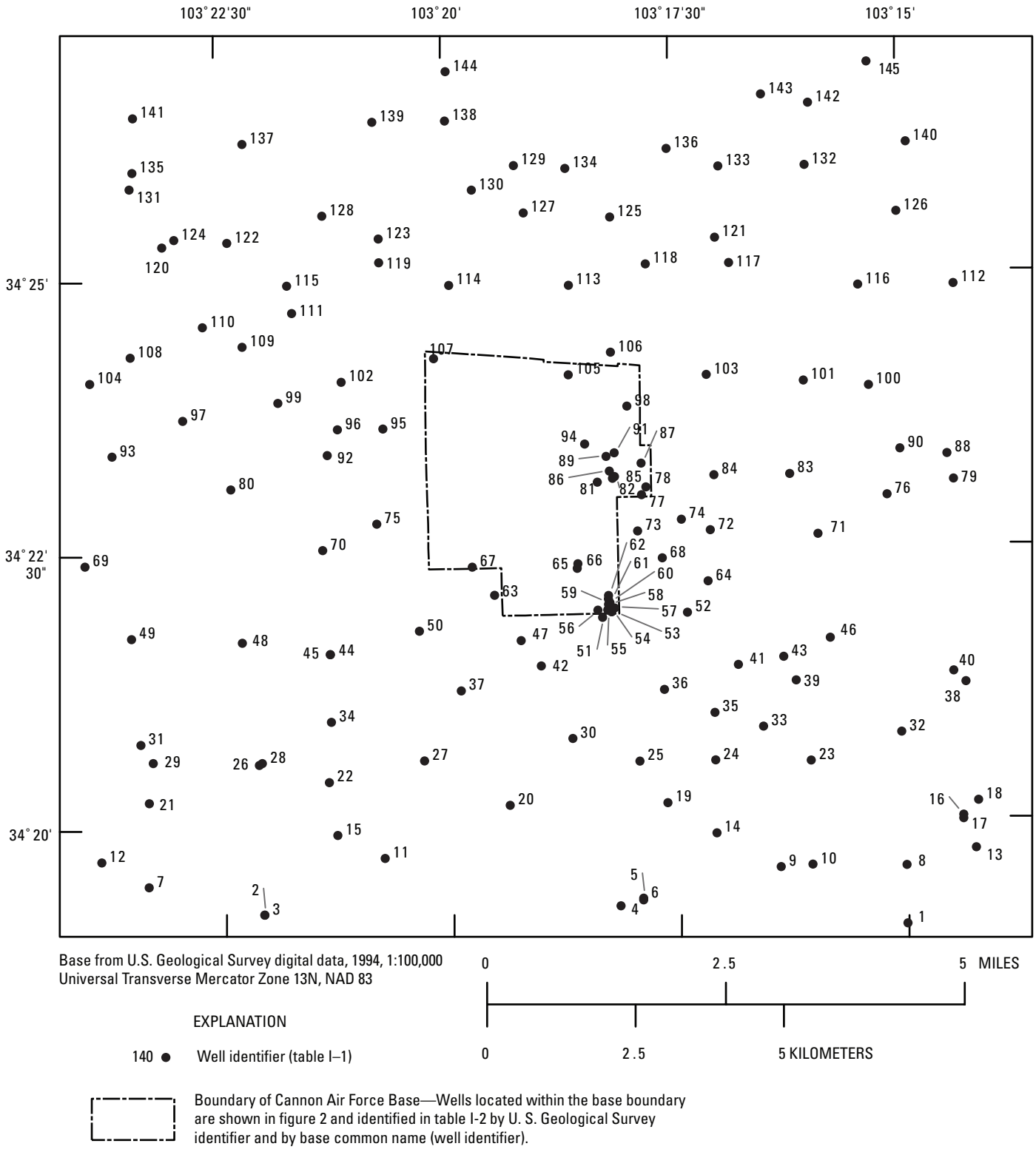

Figure I–1. Location of selected wells at Cannon Air Force Base and the surrounding area.

Table I–1. Information for selected wells at Cannon Air Force Base and the surrounding area.

[NAD 83, North American Datum of 1983; NAVD 88, North American Vertical Datum of 1988; ft, feet; bls, below land surface; --, not available]

Map identifier (fig. I–1)	U.S. Geological Survey identification number	Latitude (NAD 83)	Longitude (NAD 83)	Land-surface altitude (ft above NAVD 88)	Well depth (ft bls)
1	341903103145601	34°19′03″	103°14′58″	4,196	342
2	341913103220001	34°19′13″	103°22′02″	4,180	--
3	341913103220002	34°19′13″	103°22′02″	4,180	--
4	341915103180501	34°19′15″	103°18′07″	4,197	--
5	341918103175001	34°19′18″	103°17′52″	4,213	--
6	341919103175001	34°19′19″	103°17′52″	4,213	--
7	341929103231601	34°19′29″	103°23′18″	4,176	--
8	341935103145601	34°19′35″	103°14′58″	4,196	--
9	341935103161901	34°19′35″	103°16′21″	4,223	--
10	341936103155801	34°19′36″	103°16′00″	4,221	--
11	341943103204001	34°19′43″	103°20′42″	4,196	--
12	341943103234701	34°19′43″	103°23′49″	4,202	--
13	341944103141001	34°19′44″	103°14′12″	4,159	300
14	341954103170101	34°19′54″	103°17′03″	4,214	331
15	341956103211101	34°19′56″	103°21′13″	4,206	199
16	342000103141801	34°20′00″	103°14′20″	4,186	--
17	342002103141801	34°20′02″	103°14′20″	4,189	--
18	342010103140801	34°20′10″	103°14′10″	4,187	368
19	342011103173301	34°20′11″	103°17′35″	4,230	--
20	342011103191701	34°20′11″	103°19′19″	4,221	244
21	342015103231501	34°20′15″	103°23′17″	4,237	--
22	342025103211601	34°20′25″	103°21′18″	4,226	--
23	342033103155801	34°20′33″	103°16′00″	4,235	370
24	342034103170101	34°20′34″	103°17′03″	4,242	--
25	342034103175101	34°20′34″	103°17′53″	4,244	--
26	342035103220201	34°20′35″	103°22′04″	4,235	--
27	342036103201301	34°20′36″	103°20′15″	4,239	250
28	342036103220001	34°20′36″	103°22′02″	4,236	235
29	342037103231201	34°20′37″	103°23′14″	4,263	--
30	342047103183501	34°20′47″	103°18′37″	4,238	293
31	342047103232001	34°20′47″	103°23′22″	4,269	--
32	342048103145801	34°20′48″	103°15′00″	4,231	402
33	342052103162901	34°20′52″	103°16′31″	4,239	--
34	342058103211401	34°20′58″	103°21′16″	4,248	270
35	342100103170101	34°21′00″	103°17′03″	4,252	390
36	342113103173401	34°21′13″	103°17′36″	4,254	388
37	342114103194801	34°21′14″	103°19′50″	4,250	--
38	342115103141501	34°21′15″	103°14′17″	4,223	360
39	342117103160701	34°21′17″	103°16′09″	4,255	--
40	342121103142301	34°21′21″	103°14′25″	4,233	337
41	342126103164501	34°21′26″	103°16′47″	4,256	397
42	342127103185501	34°21′27″	103°18′57″	4,263	320
43	342130103161501	34°21′30″	103°16′17″	4,255	415
44	342135103211401	34°21′35″	103°21′16″	4,289	--
45	342135103211402	34°21′35″	103°21′16″	4,289	282
46	342140103154401	34°21′40″	103°15′46″	4,255	390
47	342140103190501	34°21′41″	103°19′10″	4,262	315

Table I–1. Information for selected wells at Cannon Air Force Base and the surrounding area.—Continued

[NAD 83, North American Datum of 1983; NAVD 88, North American Vertical Datum of 1988; ft, feet; bls, below land surface; --, not available]

Map identifier (fig. I–1)	U.S. Geological Survey identification number	Latitude (NAD 83)	Longitude (NAD 83)	Land-surface altitude (ft above NAVD 88)	Well depth (ft bls)
48	342142103221201	34°21′42″	103°22′14″	4,294	268
49	342145103232501	34°21′45″	103°23′27″	4,289	--
50	342147103201501	34°21′47″	103°20′17″	4,261	--
51	342153103181401	34°21′53″	103°18′16″	4,262	364
52	342155103171801	34°21′55″	103°17′20″	4,260	375
53	342156103180801	34°2156.67″	103°18′16.49″	4,264	360
54	342156103180802	34°21′56.24″	103°18′12.02″	4,261	303
55	342157103181101	34°21′57.00″	103°18′10.69″	4,261	365
56	342157103181701	34°21′57.13″	103°18′24.41″	4,262	355
57	342158103180601	34°21′58.94″	103°18′10.37″	4,262	291
58	342200103180901	34°22′00.07″	103°18′09.47″	4,261	365
59	342200103181001	34°21′59.94″	103°18′10.04″	4,261	287
60	342201103180901	34°22′00.98″	103°18′09.94″	4,261	285
61	342203103181001	34°22′02.67″	103°18′10.33″	4,262	362
62	342205103181001	34°22′04.81″	103°18′09.90″	4,262	365
63	342206103192501	34°22′06″	103°19′27″	4,266	318
64	342212103170401	34°22′12″	103°17′06″	4,261	355
65	342218103182601	34°22′18.91″	103°18′31.43″	4,264	340
66	342219103183101	34°22′18.98″	103°18′31.39″	4,264	294
67	342222103194301	34°22′22.16″	103°19′43.14″	4,265	340
68	342225103173401	34°22′25″	103°17′36″	4,269	365
69	342225103235501	34°22′25″	103°23′57″	4,308	--
70	342232103211801	34°22′32″	103°21′20″	4,294	289
71	342237103155101	34°22′37″	103°15′53″	4,244	323
72	342240103170201	34°22′40″	103°17′04″	4,260	323
73	342240103175001	34°22′40″	103°17′52″	4,274	365
74	342246103172101	34°22′46″	103°17′23″	4,262	340
75	342246103204201	34°22′46″	103°20′44″	4,297	--
76	342258103150501	34°22′58″	103°15′07″	4,258	338
77	342300103175001	34°23′00.33″	103°17′50.57″	4,270	370
78	342304103174401	34°23′00.24″	103°17′50.39″	4,269	304
79	342306103142101	34°23′06″	103°14′23″	4,267	350
80	342306103221801	34°23′06″	103°22′20″	4,314	--
81	342307103181601	34°23′07.71″	103°18′17.42″	4,276	372
82	342309103180601	34°23′10.42″	103°18′07.99″	4,271	295
83	342310103160901	34°23′10″	103°16′11″	4,276	332
84	342310103165901	34°23′10″	103°17′01″	4,276	335
85	342310103180801	34°23′10.49″	103°18′08.24″	4,271	370
86	342313103180801	34°23′12.85″	103°18′12.06″	4,276	368
87	342317103174701	34°23′18.11″	103°17′46.57″	4,266	297
88	342320103142501	34°23′20″	103°14′27″	4,267	--
89	342321103181001	34°23′21.29″	103°18′14.29″	4,275	355
90	342323103145601	34°23′23″	103°14′58″	4,279	--
91	342323103180801	34°23′23.50″	103°18′08.21″	4,272	--
92	342324103211401	34°23′24″	103°21′16″	4,317	415
93	342325103233601	34°23′25″	103°23′38″	4,334	328

Table I–1. Information for selected wells at Cannon Air Force Base and the surrounding area.—Continued

[NAD 83, North American Datum of 1983; NAVD 88, North American Vertical Datum of 1988; ft, feet; bls, below land surface; --, not available]

Map identifier (fig. I–1)	U.S. Geological Survey identification number	Latitude (NAD 83)	Longitude (NAD 83)	Land-surface altitude (ft above NAVD 88)	Well depth (ft bls)
94	342328103182401	34°23′26.51″	103°18′26.21″	4,280	366
95	342338103203701	34°23′38″	103°20′39″	4,329	365
96	342338103210701	34°23′38″	103°21′09″	4,337	--
97	342344103224901	34°23′44″	103°22′51″	4,330	360
98	342348103175801	34°23′48.64″	103°17′57.62″	4,297	381
99	342353103214601	34°23′53″	103°21′48″	4,341	370
100	342358103151601	34°23′58″	103°15′18″	4,309	430
101	342401103155901	34°24′01″	103°16′01″	4,314	394
102	342404103210401	34°24′04″	103°21′06″	4,353	386
103	342405103170301	34°24′05″	103°17′05″	4,305	334
104	342405103235001	34°24′05″	103°23′52″	4,357	278
105	342406103183401	34°24′06″	103°18′36″	4,325	--
106	342418103180601	34°24′18″	103°18′08″	4,315	350
107	342418103201201	34°24′18.00″	103°20′12.59″	4,325	370
108	342419103232301	34°24′19″	103°23′25″	4,362	372
109	342424103220901	34°24′24″	103°22′11″	4,363	356
110	342435103223501	34°24′35″	103°22′37″	4,364	--
111	342442103213601	34°24′42″	103°21′38″	4,365	--
112	342453103141901	34°24′53″	103°14′21″	4,319	415
113	342455103183301	34°24′55″	103°18′35″	4,344	375
114	342456103195201	34°24′56″	103°19′54″	4,354	418
115	342457103213901	34°24′57″	103°21′41″	4,365	430
116	342505103151801	34°24′53″	103°15′24″	4,336	419
117	342506103164701	34°25′06″	103°16′49″	4,345	405
118	342506103174201	34°25′06″	103°17′44″	4,349	400
119	342509103203801	34°25′09″	103°20′40″	4,369	432
120	342519103230101	34°25′19″	103°23′03″	4,394	392
121	342520103165601	34°25′20″	103°16′58″	4,356	400
122	342521103221801	34°25′21″	103°22′20″	4,381	441
123	342522103203801	34°25′22″	103°20′40″	4,373	375
124	342523103225301	34°25′23″	103°22′55″	4,391	432
125	342532103180501	34°25′32″	103°18′07″	4,362	421
126	342533103145601	34°25′33″	103°14′58″	4,335	412
127	342535103190201	34°25′35″	103°19′04″	4,360	--
128	342535103211501	34°25′35″	103°21′17″	4,391	--
129	342547103190201	34°26′01″	103°19′10″	4,375	385
130	342548103193601	34°25′48″	103°19′38″	4,384	--
131	342551103232201	34°25′51″	103°23′24″	4,400	--
132	342559103155601	34°25′59″	103°15′58″	4,357	--
133	342559103165301	34°25′59″	103°16′55″	4,366	--
134	342559103183401	34°25′59″	103°18′36″	4,370	388
135	342600103232001	34°26′00″	103°23′22″	4,409	446
136	342609103172701	34°26′09″	103°17′29″	4,381	412
137	342615103220701	34°26′15″	103°22′09″	4,424	406
138	342626103195301	34°26′26″	103°19′55″	4,394	387
139	342626103204101	34°26′26″	103°20′43″	4,407	402

Table I–1. Information for selected wells at Cannon Air Force Base and the surrounding area.—Continued

[NAD 83, North American Datum of 1983; NAVD 88, North American Vertical Datum of 1988; ft, feet; bls, below land surface; --, not available]

Map identifier (fig. I–1)	U.S. Geological Survey identification number	Latitude (NAD 83)	Longitude (NAD 83)	Land-surface altitude (ft above NAVD 88)	Well depth (ft bls)
140	342630103145201	34°26′11″	103°14′51″	4,347	387
141	342630103231901	34°26′30″	103°23′21″	4,422	433
142	342633103155301	34°26′33″	103°15′55″	4,369	396
143	342638103162401	34°26′38″	103°16′26″	4,378	395
144	342653103195201	34°26′53″	103°19′54″	4,406	415
145	342655103151401	34°26′55″	103°15′16″	4,364	--

Table I–2. Altitudes of water levels in selected wells at Cannon Air Force Base and the surrounding area.

[Monitoring well, Cannon Air Force Base monitoring well; Primary use of water: I, irrigation; O, observation; S, stock watering; U, unused; Z, other; W, withdrawal; ---, not recorded]

Map identifier (fig. I–1)	U.S. Geological Survey identifier	Township and range	Primary use of water	Water-level date	Altitude of land surface (feet above NAVD 88)	Water level (feet below land surface)	Altitude of water level (feet above NAVD 88)
1	341903103145601	01N.35E.11.33333	I	01/09/80	4,196	203.75	3,992
				01/12/81	4,196	207.55	3,988
				01/11/82	4,196	210.31	3,986
				01/10/83	4,196	213.70	3,982
				01/07/87	4,196	221.84	3,974
2	341913103220001	01N.34E.10.31244	S	01/17/62	4,180	121.91	4,058
				02/02/67	4,180	120.97	4,059
3	341913103220002	01N.34E.10.31244A	S	01/21/77	4,180	133.37	4,047
				03/10/82	4,180	138.44	4,042
4	341915103180501	01N.35E.07.42224	S	01/13/61	4,197	157.03	4,040
				01/17/62	4,197	157.66	4,039
				01/28/67	4,197	161.45	4,036
5	341918103175001	01N.35E.08.13444	U	01/13/61	4,213	175.70	4,037
				01/17/62	4,213	180.14	4,033
				01/28/67	4,213	181.22	4,032
6	341919103175001	01N.35E.08.13442	I	01/18/77	4,213	198.33	4,015
				03/09/82	4,213	206.88	4,006
				01/08/87	4,213	213.86	3,999
				02/20/97	4,213	229.89	3,983
7	341929103231601	01N.34E.08.42222	I	03/30/82	4,176	111.37	4,065
				02/06/87	4,176	113.39	4,063
8	341935103145601	01N.35E.11.1331	U	01/19/84	4,196	223.04	3,973
				01/13/85	4,196	224.42	3,972
				01/13/86	4,196	226.14	3,970
				01/13/87	4,196	228.43	3,968
				01/13/88	4,196	230.35	3,966
				01/04/90	4,196	235.23	3,961
				01/05/91	4,196	239.02	3,957

Table I–2. Altitudes of water levels in selected wells at Cannon Air Force Base and the surrounding area.—Continued

[Monitoring well, Cannon Air Force Base monitoring well; Primary use of water: I, irrigation; O, observation; S, stock watering; U, unused; Z, other; W, withdrawal; ---, not recorded]

Map identifier (fig. I–1)	U.S. Geological Survey identifier	Township and range	Primary use of water	Water-level date	Altitude of land surface (feet above NAVD 88)	Water level (feet below land surface)	Altitude of water level (feet above NAVD 88)
				01/04/92	4,196	242.00	3,954
				01/05/93	4,196	256.54	3,939
				01/05/94	4,196	265.10	3,931
				01/08/95	4,196	255.45	3,941
				01/11/96	4,196	261.19	3,935
				01/24/97	4,196	265.26	3,931
				01/07/98	4,196	269.05	3,927
9	341935103161901	01N.35E.09.21412	I	01/25/67	4,223	204.93	4,018
10	341936103155801	01N.35E.10.113111	I	03/13/72	4,221	208.99	4,012
				01/07/77	4,221	219.73	4,001
				03/09/82	4,221	233.52	3,987
				01/07/87	4,221	243.09	3,978
				02/19/97	4,221	273.56	3,947
11	341943103204001	01N.34E.11.21113	---	01/17/62	4,196	138.20	4,058
12	341943103234701	01N.34E.08.211143	S	01/12/61	4,202	131.53	4,070
				01/17/62	4,202	129.68	4,072
13	341944103141001	01N.35E.11.232	I	01/08/94	4,159	218.42	3,941
				01/08/95	4,159	224.87	3,934
				01/24/97	4,159	235.58	3,923
14	341954103170101	01N.35E.09.11111	U	03/16/82	4,214	214.50	4,000
				01/07/87	4,214	223.50	3,991
15	341956103211101	01N.34E.03.40000	I	03/26/87	4,206	166.01	4,040
16	342000103141801	01N.35E.02.433	I	---	4,186	---	---
17	342002103141801	01N.35E.02.43144	I	03/16/82	4,189	211.72	3,977
				03/03/87	4,189	221.16	3,968
18	342010103140801	01N.35E.02.42333	I	12/10/92	4,187	234.00	3,953
19	342011103173301	01N.35E.05.23331	S	02/27/62	4,230	193.44	4,037
				01/28/67	4,230	202.28	4,028
20	342011103191701	01N.34E.01.24344	I	01/19/77	4,221	193.75	4,027
				03/30/82	4,221	198.30	4,023
				01/08/87	4,221	202.45	4,019
				01/04/91	4,221	217.72	4,003
				01/03/92	4,221	218.51	4,002
				01/05/93	4,221	219.20	4,002
				01/05/94	4,221	220.28	4,001
				01/04/95	4,221	221.85	3,999
				01/23/97	4,221	223.61	3,997
21	342015103231501	01N.34E.04.133322	S	01/21/77	4,237	169.56	4,067
				03/30/82	4,237	172.76	4,064
				02/06/87	4,237	175.52	4,061
22	342025103211601	01N.34E.03.22443	S	01/12/60	4,226	130.84	4,095
				01/12/61	4,226	140.67	4,085

Table I–2. Altitudes of water levels in selected wells at Cannon Air Force Base and the surrounding area.—Continued

[Monitoring well, Cannon Air Force Base monitoring well; Primary use of water: I, irrigation; O, observation; S, stock watering; U, unused; Z, other; W, withdrawal; ---, not recorded]

Map identifier (fig. I–1)	U.S. Geological Survey identifier	Township and range	Primary use of water	Water-level date	Altitude of land surface (feet above NAVD 88)	Water level (feet below land surface)	Altitude of water level (feet above NAVD 88)
				01/16/62	4,226	168.68	4,057
				01/26/67	4,226	168.76	4,057
				01/18/72	4,226	179.28	4,047
23	342033103155801	01N.35E.03.11111	I	02/26/69	4,235	216.89	4,018
				01/06/70	4,235	218.75	4,016
				01/05/71	4,235	221.84	4,013
				01/05/72	4,235	223.37	4,012
				01/04/73	4,235	225.23	4,010
				01/04/74	4,235	226.24	4,009
				01/04/75	4,235	229.87	4,005
				01/06/76	4,235	231.50	4,004
				01/06/77	4,235	234.62	4,000
				01/05/78	4,235	240.51	3,994
				01/05/79	4,235	239.57	3,995
				01/09/80	4,235	240.93	3,994
				01/10/81	4,235	245.78	3,989
				01/11/82	4,235	247.09	3,988
				01/10/83	4,235	248.56	3,986
				01/16/84	4,235	249.65	3,985
				01/13/85	4,235	247.86	3,987
				01/13/87	4,235	255.25	3,980
				01/12/88	4,235	255.75	3,979
				01/04/90	4,235	260.95	3,974
				01/05/91	4,235	263.97	3,971
				01/07/92	4,235	270.41	3,965
				01/08/93	4,235	268.84	3,966
				01/08/95	4,235	276.62	3,958
				01/11/96	4,235	280.29	3,955
				01/24/97	4,235	284.02	3,951
				01/06/98	4,235	287.51	3,947
				02/20/03	4,235	312.05	3,923
				03/06/04	4,235	298.14	3,937
24	342034103170101	01N.35E.04.11111	I	02/26/63	4,242	207.37	4,035
				01/10/64	4,242	208.55	4,033
				01/25/67	4,242	218.15	4,024
				03/13/72	4,242	228.85	4,013
				01/18/77	4,242	240.79	4,001
				03/09/82	4,242	249.36	3,993
				03/12/87	4,242	258.14	3,984
25	342034103175101	01N.35E.05.11222	I	01/26/77	4,244	237.22	4,007
				03/09/82	4,244	245.54	3,998
				01/08/87	4,244	253.40	3,991

Table I–2. Altitudes of water levels in selected wells at Cannon Air Force Base and the surrounding area.—Continued

[Monitoring well, Cannon Air Force Base monitoring well; Primary use of water: I, irrigation; O, observation; S, stock watering; U, unused; Z, other; W, withdrawal; ---, not recorded]

Map identifier (fig. I–1)	U.S. Geological Survey identifier	Township and range	Primary use of water	Water-level date	Altitude of land surface (feet above NAVD 88)	Water level (feet below land surface)	Altitude of water level (feet above NAVD 88)
				02/07/97	4,244	283.97	3,960
				03/06/04	4,244	302.36	3,942
26	342035103220201	01N.34E.03.11224	S	01/17/62	4,235	173.56	4,061
				01/26/67	4,235	172.47	4,063
27	342036103201301	01N.34E.02.222221	I	12/16/71	4,239	197.76	4,041
				01/19/77	4,239	202.38	4,037
				03/30/82	4,239	206.82	4,032
				03/11/87	4,239	209.62	4,029
28	342036103220001	01N.34E.03.12111	I	01/10/67	4,236	172.47	4,064
				02/01/68	4,236	175.10	4,061
				01/07/69	4,236	176.77	4,059
				01/06/70	4,236	179.39	4,057
				01/05/71	4,236	183.42	4,053
				12/16/71	4,236	182.08	4,054
				01/05/72	4,236	188.24	4,048
				01/04/73	4,236	181.26	4,055
				01/03/74	4,236	186.72	4,049
				01/03/75	4,236	184.78	4,051
				01/06/76	4,236	187.37	4,049
				01/05/77	4,236	185.49	4,051
				01/05/78	4,236	189.62	4,046
				01/05/79	4,236	187.66	4,048
				01/07/80	4,236	190.34	4,046
				01/10/81	4,236	189.65	4,046
				01/11/82	4,236	188.97	4,047
				01/10/83	4,236	190.33	4,046
				01/18/84	4,236	191.20	4,045
				01/13/85	4,236	190.40	4,046
				01/09/87	4,236	191.00	4,045
				01/12/87	4,236	191.00	4,045
				01/03/90	4,236	190.83	4,045
				01/04/91	4,236	191.27	4,045
				01/02/92	4,236	191.08	4,045
				01/05/93	4,236	191.00	4,045
				01/05/94	4,236	190.99	4,045
				01/04/95	4,236	191.97	4,044
				01/11/96	4,236	191.98	4,044
				01/24/97	4,236	192.23	4,044
				02/02/98	4,236	192.14	4,044
				02/20/03	4,236	205.98	4,030
				03/06/04	4,236	195.53	4,040
29	342037103231201	01N.34E.04.11122	U	01/26/67	4,263	190.80	4,072

Table I–2. Altitudes of water levels in selected wells at Cannon Air Force Base and the surrounding area.—Continued

[Monitoring well, Cannon Air Force Base monitoring well; Primary use of water: I, irrigation; O, observation; S, stock watering; U, unused; Z, other; W, withdrawal; ---, not recorded]

Map identifier (fig. I–1)	U.S. Geological Survey identifier	Township and range	Primary use of water	Water-level date	Altitude of land surface (feet above NAVD 88)	Water level (feet below land surface)	Altitude of water level (feet above NAVD 88)
				03/27/72	4,263	193.55	4,069
30	342047103183501	01N.35E.06.12222	I	03/16/82	4,238	228.49	4,010
				01/08/87	4,238	233.62	4,004
31	342047103232001	02N.34E.32.44242	S	01/12/61	4,269	191.00	4,078
				01/17/62	4,269	199.46	4,070
				01/12/72	4,269	198.79	4,070
				01/05/77	4,269	202.17	4,067
32	342048103145801	02N.35E.34.40000	I	01/28/82	4,231	253.99	3,977
				01/15/87	4,231	262.29	3,969
33	342052103162901	01N.35E.04.211	I	---	4,239	---	---
34	342058103211401	02N.34E.35.33131	I	02/11/82	4,248	206.16	4,042
				02/05/87	4,248	207.72	4,040
35	342100103170101	02N.35E.33.31111	I	01/07/77	4,252	249.75	4,002
36	342113103173401	02N.35E.32.411113	I	07/08/75	4,254	252.55	4,001
				02/16/82	4,254	262.76	3,991
				01/15/87	4,254	268.88	3,985
37	342114103194801	02N.34E.36.32211	I	02/17/82	4,250	228.39	4,022
				02/05/87	4,250	230.90	4,019
38	342115103141501	02N.35E.35.234334	I	03/16/93	4,223	260.00	3,963
39	342117103160701	02N.35E.33.22324	Z	02/27/62	4,255	226.05	4,029
				01/16/67	4,255	246.90	4,008
				01/07/77	4,255	259.00	3,996
40	342121103142301	02N.35E.35.21131	I	02/27/62	4,233	208.28	4,025
				01/17/67	4,233	251.26	3,982
				01/07/69	4,233	223.75	4,009
				01/06/70	4,233	225.83	4,007
				01/05/71	4,233	231.41	4,002
				01/05/72	4,233	234.02	3,999
				01/04/73	4,233	235.68	3,997
				01/04/74	4,233	234.88	3,998
				01/04/75	4,233	237.92	3,995
				01/06/76	4,233	238.99	3,994
				01/06/77	4,233	242.06	3,991
				01/05/78	4,233	244.81	3,988
				01/05/79	4,233	247.34	3,986
				01/07/80	4,233	252.09	3,981
				01/11/82	4,233	257.05	3,976
				01/10/83	4,233	259.30	3,974
				01/19/84	4,233	261.94	3,971
				01/14/85	4,233	263.37	3,970
				01/12/87	4,233	263.37	3,970
				01/13/88	4,233	263.40	3,970

Table I–2. Altitudes of water levels in selected wells at Cannon Air Force Base and the surrounding area.—Continued

[Monitoring well, Cannon Air Force Base monitoring well; Primary use of water: I, irrigation; O, observation; S, stock watering; U, unused; Z, other; W, withdrawal; ---, not recorded]

Map identifier (fig. I–1)	U.S. Geological Survey identifier	Township and range	Primary use of water	Water-level date	Altitude of land surface (feet above NAVD 88)	Water level (feet below land surface)	Altitude of water level (feet above NAVD 88)
				01/04/90	4,233	276.42	3,957
				01/05/91	4,233	268.91	3,964
				01/05/93	4,233	274.08	3,959
				01/05/94	4,233	275.58	3,957
				01/04/95	4,233	278.65	3,954
				01/11/96	4,233	283.90	3,949
				01/14/97	4,233	288.21	3,945
				01/07/98	4,233	290.55	3,942
				03/05/04	4,233	300.08	3,933
41	342126103164501	02N.35E.33.12111	I	01/05/75	4,256	253.72	4,002
				01/06/76	4,256	254.55	4,001
				01/06/77	4,256	257.59	3,998
				01/05/78	4,256	260.82	3,995
				01/05/79	4,256	260.46	3,996
				01/07/80	4,256	261.77	3,994
				01/10/81	4,256	266.45	3,990
				01/11/82	4,256	267.30	3,989
				01/10/83	4,256	268.47	3,988
				01/18/84	4,256	268.73	3,987
				01/13/85	4,256	269.39	3,987
				01/13/86	4,256	271.63	3,984
				01/12/87	4,256	272.32	3,984
				01/12/88	4,256	272.95	3,983
				01/04/90	4,256	276.14	3,980
				01/05/91	4,256	276.63	3,979
				01/02/92	4,256	278.72	3,977
				01/05/93	4,256	281.52	3,974
				01/05/94	4,256	284.70	3,971
				01/04/95	4,256	289.31	3,967
				01/11/96	4,256	293.17	3,963
				01/14/97	4,256	296.21	3,960
				01/06/98	4,256	299.50	3,957
42	342127103185501	02N.35E.31.11221	I	01/16/67	4,263	234.80	4,028
				01/11/72	4,263	242.02	4,021
				01/11/77	4,263	249.59	4,013
				02/09/82	4,263	258.32	4,005
43	342130103161501	02N.35E.33.22313	I	02/10/82	4,255	268.45	3,987
44	342135103211401	02N.34E.27.44422	W	02/06/67	4,289	227.97	4,061
				01/11/72	4,289	231.39	4,058
45	342135103211402	02N.34E.27.444224	W	01/05/77	4,289	233.95	4,055
				02/12/82	4,289	240.83	4,048

Table I–2. Altitudes of water levels in selected wells at Cannon Air Force Base and the surrounding area.—Continued

[Monitoring well, Cannon Air Force Base monitoring well; Primary use of water: I, irrigation; O, observation; S, stock watering; U, unused; Z, other; W, withdrawal; ---, not recorded].

Map identifier (fig. I–1)	U.S. Geological Survey identifier	Township and range	Primary use of water	Water-level date	Altitude of land surface (feet above NAVD 88)	Water level (feet below land surface)	Altitude of water level (feet above NAVD 88)
				03/06/85	4,289	242.90	4,046
				02/06/87	4,289	244.19	4,045
46	342140103154401	02N.35E.27.34333	I	01/28/82	4,255	271.15	3,984
				01/15/87	4,255	276.84	3,978
47	342140103190501	02N.34E.36.222221	I	02/10/54	4,262	214.14	4,048
				01/05/56	4,262	217.47	4,045
				01/11/57	4,262	218.14	4,044
				01/13/58	4,262	217.13	4,045
				01/12/59	4,262	216.84	4,045
				01/15/60	4,262	216.70	4,045
				03/06/62	4,262	216.16	4,046
				01/22/63	4,262	218.34	4,044
				01/10/64	4,262	219.94	4,042
				02/17/65	4,262	227.71	4,034
				01/05/67	4,262	227.15	4,035
				01/23/67	4,262	227.02	4,035
				01/11/68	4,262	231.04	4,031
				01/07/69	4,262	233.26	4,029
				01/06/70	4,262	234.62	4,027
				01/05/72	4,262	239.06	4,023
				01/04/73	4,262	239.14	4,023
				01/03/74	4,262	245.73	4,016
				01/04/75	4,262	243.22	4,019
				01/06/76	4,262	247.96	4,014
				01/06/77	4,262	246.23	4,016
				01/05/78	4,262	250.07	4,012
				01/05/79	4,262	249.31	4,013
				01/07/80	4,262	252.78	4,009
				01/11/82	4,262	255.76	4,006
				01/10/83	4,262	256.52	4,005
				01/18/84	4,262	259.66	4,002
				01/13/85	4,262	256.96	4,005
				01/13/86	4,262	260.20	4,002
				01/12/87	4,262	258.94	4,003
				01/12/88	4,262	255.07	4,007
				01/03/90	4,262	258.12	4,004
				01/04/91	4,262	258.41	4,004
				01/02/92	4,262	256.75	4,005
				01/05/93	4,262	257.95	4,004
				01/05/94	4,262	259.47	4,003
				01/04/95	4,262	262.80	3,999
				01/17/97	4,262	266.11	3,996

Table I–2. Altitudes of water levels in selected wells at Cannon Air Force Base and the surrounding area.—Continued

[Monitoring well, Cannon Air Force Base monitoring well; Primary use of water: I, irrigation; O, observation; S, stock watering; U, unused; Z, other; W, withdrawal; ---, not recorded]

Map identifier (fig. I–1)	U.S. Geological Survey identifier	Township and range	Primary use of water	Water-level date	Altitude of land surface (feet above NAVD 88)	Water level (feet below land surface)	Altitude of water level (feet above NAVD 88)
				01/06/98	4,262	268.99	3,993
				03/04/04	4,262	276.02	3,986
48	342142103221201	02N.34E.27.333432	I	02/17/82	4,294	239.82	4,054
				02/05/87	4,294	242.24	4,052
				03/13/92	4,294	242.84	4,051
				03/06/97	4,294	242.59	4,051
				03/14/02	4,294	239.39	4,055
49	342145103232501	02N.34E.29.42430	U	03/08/62	4,289	219.09	4,070
				01/26/67	4,289	213.68	4,075
				01/12/72	4,289	217.15	4,072
				01/05/77	4,289	219.90	4,069
50	342147103201501	02N.34E.26.44421	W	02/17/82	4,261	229.07	4,032
				02/10/87	4,261	233.98	4,027
51	342153103181401	02N.35E.30.42344	I	02/10/82	4,262	259.91	4,002
				01/15/87	4,262	264.13	3,998
52	342155103171801	02N.35E.29.44111	I	02/12/94	4,260	250.00	4,010
53	342156103180801	02N.35E.30.4244	O	04/06/98	4,263.72	289.19	3,974.53
		(Monitoring well C)		03/02/99	4,263.72	293.85	3,969.87
				08/29/99	4,263.72	295.35	3,968.37
				03/01/00	4,263.72	292.13	3,971.59
				08/10/00	4,263.72	299.64	3,964.08
				03/23/01	4,263.72	296.07	3,967.65
				08/22/01	4,263.72	300.93	3,962.79
				03/13/02	4,263.72	296.42	3,967.30
				08/13/02	4,263.72	305.61	3,958.11
				03/20/03	4,263.72	302.11	3,961.61
				08/20/03	4,263.72	307.36	3,956.36
				06/15/04	4,263.72	308.30	3,955.42
				10/21/04	4,263.72	306.04	3,957.68
				01/10/05	4,263.72	305.25	3,958.47
54	342156103180802	02N.35E.30.424A	O	---	4,261.11	---	---
		(Monitoring well J)					
55	342157103181101	02N.35E.30.424E	O	03/02/99	4,260.72	289.12	3,971.60
		(Monitoring well S)		08/29/99	4,260.72	290.92	3,969.80
				02/29/00	4,260.72	289.71	3,971.01
				08/10/00	4,260.72	294.23	3,966.49
				03/29/01	4,260.72	293.80	3,966.92
				08/21/01	4,260.72	295.66	3,965.06
				03/13/02	4,260.72	294.37	3,966.35
				08/15/02	4,260.72	299.69	3,961.03
				03/19/03	4,260.72	297.13	3,963.59
				08/19/03	4,260.72	301.98	3,958.74

Table I–2. Altitudes of water levels in selected wells at Cannon Air Force Base and the surrounding area.—Continued

[Monitoring well, Cannon Air Force Base monitoring well; Primary use of water: I, irrigation; O, observation; S, stock watering; U, unused; Z, other; W, withdrawal; ---, not recorded]

Map identifier (fig. I–1)	U.S. Geological Survey identifier	Township and range	Primary use of water	Water-level date	Altitude of land surface (feet above NAVD 88)	Water level (feet below land surface)	Altitude of water level (feet above NAVD 88)
				02/27/04	4,260.72	299.83	3,960.89
				06/14/04	4,260.72	303.62	3,957.10
				08/12/04	4,260.72	304.24	3,956.48
				10/21/04	4,260.72	304.42	3,956.30
				01/10/05	4,260.72	303.68	3,957.04
56	342157103181701	02N.35E.30.423 (Monitoring well D)	O	03/02/99	4,261.94	287.22	3,974.72
				08/29/99	4,261.94	289.08	3,972.86
				03/01/00	4,261.94	288.23	3,973.71
				08/10/00	4,261.94	292.44	3,969.50
				03/21/01	4,261.94	291.73	3,970.21
				08/22/01	4,261.94	293.99	3,967.95
				03/12/02	4,261.94	292.44	3,969.50
				08/13/02	4,261.94	298.24	3,963.70
				03/20/03	4,261.94	297.14	3,964.80
				08/20/03	4,261.94	300.05	3,961.89
				06/16/04	4,261.94	301.38	3,960.56
				10/21/04	4,261.94	301.53	3,960.41
				01/10/05	4,261.94	300.68	3,961.26
57	342158103180601	02N.35E.30.4242D (Monitoring well I)	O	02/21/94	4,261.57	270.95	3,990.62
				08/09/94	4,261.57	273.32	3,988.25
				02/23/95	4,261.57	275.17	3,986.40
				08/22/95	4,261.57	276.42	3,985.15
				02/29/96	4,261.57	278.18	3,983.39
				08/19/96	4,261.57	280.59	3,980.98
				12/17/96	4,261.57	280.51	3,981.06
				03/05/97	4,261.57	281.41	3,980.16
				05/28/97	4,261.57	281.65	3,979.92
				08/18/97	4,261.57	283.13	3,978.44
				04/06/98	4,261.57	284.81	3,976.76
				08/12/98	4,261.57	288.20	3,973.37
				03/02/99	4,261.57	289.17	3,972.40
				08/29/99	4,261.57	291.01	3,970.56
				02/28/00	4,261.57	290.23	3,971.34
58	342200103180901	02N.35E.30.424F (Monitoring well T)	O	03/02/99	4,260.82	288.70	3,972.12
				08/29/99	4,260.82	289.84	3,970.98
				02/29/00	4,260.82	289.29	3,971.53
				08/10/00	4,260.82	292.90	3,967.92
				03/20/01	4,260.82	292.93	3,967.89
				08/21/01	4,260.82	294.47	3,966.35
				03/13/02	4,260.82	293.84	3,966.98
				08/15/02	4,260.82	297.99	3,962.83
				03/19/03	4,260.82	297.40	3,963.42

Table I–2. Altitudes of water levels in selected wells at Cannon Air Force Base and the surrounding area.—Continued

[Monitoring well, Cannon Air Force Base monitoring well; Primary use of water: I, irrigation; O, observation; S, stock watering; U, unused; Z, other; W, withdrawal; ---, not recorded]

Map identifier (fig. I–1)	U.S. Geological Survey identifier	Township and range	Primary use of water	Water-level date	Altitude of land surface (feet above NAVD 88)	Water level (feet below land surface)	Altitude of water level (feet above NAVD 88)
				08/19/03	4,260.82	300.51	3,960.31
				06/15/04	4,260.82	302.41	3,958.41
				08/12/04	4,260.82	302.99	3,957.83
				10/21/04	4,260.82	303.50	3,957.32
				01/10/05	4,260.82	302.89	3,957.93
59	342200103181001	02N.35E.30.4242C	O	02/21/94	4,261.28	272.67	3,988.61
		(Monitoring well M)		08/09/94	4,261.28	272.97	3,988.31
				02/23/95	4,261.28	274.72	3,986.56
				08/22/95	4,261.28	276.79	3,984.49
				02/29/96	4,261.28	277.85	3,983.43
				08/19/96	4,261.28	280.37	3,980.91
				12/17/96	4,261.28	280.67	3,980.61
				03/04/97	4,261.28	280.69	3,980.59
				05/27/97	4,261.28	281.29	3,979.99
				08/19/97	4,261.28	282.71	3,978.57
				08/06/98	4,261.28	283.07	3,978.21
60	342201103180901	02N.35E.30.4242B	O	02/21/94	4,261.38	271.05	3,990.33
		(Monitoring well L)		08/09/94	4,261.38	273.42	3,987.96
				02/23/95	4,261.38	275.23	3,986.15
				08/22/95	4,261.38	276.47	3,984.91
				02/28/96	4,261.38	278.23	3,983.15
				08/19/96	4,261.38	280.46	3,980.92
				12/16/96	4,261.38	280.50	3,980.88
				03/05/97	4,261.38	281.37	3,980.01
				05/28/97	4,261.38	281.64	3,979.74
				08/19/97	4,261.38	283.08	3,978.30
61	342203103181001	02N.35E.30.4242A	O	02/21/94	4,262.10	270.29	3,991.81
		(Monitoring well B)		02/22/95	4,262.10	274.06	3,988.04
				08/23/95	4,262.10	275.25	3,986.85
				03/04/97	4,262.10	281.32	3,980.78
				05/29/97	4,262.10	281.54	3,980.56
				07/23/97	4,262.10	282.59	3,979.51
				08/21/97	4,262.10	283.13	3,978.97
				10/29/97	4,262.10	284.55	3,977.55
				01/05/98	4,262.10	283.95	3,978.15
				04/06/98	4,262.10	284.85	3,977.25
				08/12/98	4,262.10	288.03	3,974.07
				12/07/98	4,262.10	289.14	3,972.96
				03/01/99	4,262.10	288.45	3,973.65
				03/03/99	4,262.10	285.65	3,976.45
				08/29/99	4,262.10	289.30	3,972.80
				09/22/99	4,262.10	290.56	3,971.54

Table I–2. Altitudes of water levels in selected wells at Cannon Air Force Base and the surrounding area.—Continued

[Monitoring well, Cannon Air Force Base monitoring well; Primary use of water: I, irrigation; O, observation; S, stock watering; U, unused; Z, other; W, withdrawal; ---, not recorded]

Map identifier (fig. I–1)	U.S. Geological Survey identifier	Township and range	Primary use of water	Water-level date	Altitude of land surface (feet above NAVD 88)	Water level (feet below land surface)	Altitude of water level (feet above NAVD 88)
				03/01/00	4,262.10	290.25	3,971.85
				08/09/00	4,262.10	293.18	3,968.92
				09/22/00	4,262.10	293.40	3,968.70
				01/31/01	4,262.10	291.87	3,970.23
				03/21/01	4,262.10	293.31	3,968.79
				07/17/01	4,262.10	294.62	3,967.48
				08/21/01	4,262.10	292.33	3,969.77
				03/13/02	4,262.10	294.35	3,967.75
				08/15/02	4,262.10	298.10	3,964.00
				03/18/03	4,262.10	297.95	3,964.15
				08/20/03	4,262.10	300.65	3,961.45
				11/04/03	4,262.10	299.47	3,962.63
				12/15/03	4,262.10	300.91	3,961.19
				02/27/04	4,262.10	298.82	3,963.28
				05/26/04	4,262.10	301.76	3,960.34
				06/16/04	4,262.10	302.23	3,959.87
				08/12/04	4,262.10	302.90	3,959.20
				10/21/04	4,262.10	303.45	3,958.65
				01/10/05	4,262.10	302.93	3,959.17
62	342205103181001	02N.35E.30.422 (Monitoring well U)	O	03/02/99	4,262.27	288.67	3,973.60
				08/29/99	4,262.27	289.55	3,972.72
				02/29/00	4,262.27	289.12	3,973.15
				08/10/00	4,262.27	292.19	3,970.08
				03/20/01	4,262.27	292.51	3,969.76
				08/21/01	4,262.27	293.74	3,968.53
				03/13/02	4,262.27	293.68	3,968.59
				08/15/02	4,262.27	296.97	3,965.30
				03/19/03	4,262.27	297.34	3,964.93
				08/19/03	4,262.27	299.54	3,962.73
				06/16/04	4,262.27	301.50	3,960.77
				08/12/04	4,262.27	302.10	3,960.17
				10/21/04	4,262.27	302.80	3,959.47
				01/10/05	4,262.27	302.35	3,959.92
63	342206103192501	02N.34E.25.412222	I	02/11/82	4,266	251.60	4,014
				02/06/87	4,266	255.15	4,011
64	342212103170401	02N.35E.29.242443	I	01/27/87	4,261	266.73	3,994
65	342218103182601	02N.35E.30.23213 (Monitoring well A)	O	02/21/94	4,263.83	266.82	3,997.01
				08/09/94	4,263.83	268.31	3,995.52
				02/22/95	4,263.83	269.76	3,994.07
				08/21/95	4,263.83	271.33	3,992.50
				02/28/96	4,263.83	273.17	3,990.66
				08/22/01	4,263.83	285.93	3,977.90

Table I–2. Altitudes of water levels in selected wells at Cannon Air Force Base and the surrounding area.—Continued

[Monitoring well, Cannon Air Force Base monitoring well; Primary use of water: I, irrigation; O, observation; S, stock watering; U, unused; Z, other; W, withdrawal; ---, not recorded]

Map identifier (fig. I–1)	U.S. Geological Survey identifier	Township and range	Primary use of water	Water-level date	Altitude of land surface (feet above NAVD 88)	Water level (feet below land surface)	Altitude of water level (feet above NAVD 88)
				03/12/02	4,263.83	286.92	3,976.91
				08/20/03	4,263.83	290.94	3,972.89
				11/04/03	4,263.83	291.41	3,972.42
				12/15/03	4,263.83	291.89	3,971.94
				02/27/04	4,263.83	290.35	3,973.48
				05/26/04	4,263.83	292.59	3,971.24
				06/16/04	4,263.83	292.82	3,971.01
				08/12/04	4,263.83	293.15	3,970.68
				10/21/04	4,263.83	293.73	3,970.10
				01/10/05	4,263.83	293.88	3,969.95
66	342219103183101	02N.35E.30.23211 (Monitoring well Q)	O	02/27/96	4,263.50	272.03	3,991.47
				11/19/96	4,263.50	274.27	3,989.23
				03/04/97	4,263.50	275.07	3,988.43
				05/27/97	4,263.50	275.58	3,987.92
				08/18/97	4,263.50	276.17	3,987.33
				04/06/98	4,263.50	277.79	3,985.71
				08/12/98	4,263.50	280.30	3,983.20
				03/02/99	4,263.50	281.45	3,982.05
				08/29/99	4,263.50	282.37	3,981.13
				02/28/00	4,263.50	282.85	3,980.65
				08/10/00	4,263.50	284.17	3,979.33
				03/20/01	4,263.50	285.59	3,977.91
				08/22/01	4,263.50	286.02	3,977.48
				03/12/02	4,263.50	286.99	3,976.51
				08/13/02	4,263.50	288.43	3,975.07
				03/19/03	4,263.50	289.89	3,973.61
				08/19/03	4,263.50	290.89	3,972.61
67	342222103194301	02N.34E.25.124 (Monitoring well X)	O	03/11/04	4,264.76	270.26	3,994.50
				04/20/04	4,264.76	270.10	3,994.66
				06/15/04	4,264.76	270.71	3,994.05
				10/21/04	4,264.76	271.21	3,993.55
				01/10/05	4,264.76	270.12	3,994.64
68	342225103173401	02N.35E.29.21133	I	02/11/54	4,269	222.78	4,046
69	342225103235501	02N.34E.29.12421	I	02/12/82	4,308	234.79	4,073
				02/06/87	4,308	233.33	4,075
70	342232103211801	02N.34E.27.22221	S	02/26/82	4,294	255.90	4,038
				02/05/87	4,294	260.32	4,034
				02/10/87	4,294	260.04	4,034
71	342237103155101	02N.35E.22.334111	I	01/28/82	4,244	254.23	3,990
				01/15/87	4,244	259.17	3,985
72	342240103170201	02N.35E.21.331313	I	02/10/82	4,260	260.83	3,999

Table I–2. Altitudes of water levels in selected wells at Cannon Air Force Base and the surrounding area.—Continued

[Monitoring well, Cannon Air Force Base monitoring well; Primary use of water: I, irrigation; O, observation; S, stock watering; U, unused; Z, other; W, withdrawal; ---, not recorded].

Map identifier (fig. I–1)	U.S. Geological Survey identifier	Township and range	Primary use of water	Water-level date	Altitude of land surface (feet above NAVD 88)	Water level (feet below land surface)	Altitude of water level (feet above NAVD 88)
73	342240103175001	02N.35E.20.312432	I	02/10/54	4,274	223.96	4,050
				02/27/62	4,274	227.92	4,046
				01/16/67	4,274	237.08	4,037
				02/16/72	4,274	248.99	4,025
				01/07/77	4,274	260.62	4,013
				02/10/82	4,274	263.24	4,011
				01/15/87	4,274	268.71	4,005
74	342246103172101	02N.35E.20.23434	I	01/12/72	4,262	242.85	4,019
				01/07/77	4,262	249.56	4,012
				02/11/82	4,262	255.29	4,007
75	342246103204201	02N.34E.23.32222	U	01/27/77	4,297	308.95	3,988
				02/17/82	4,297	265.64	4,031
				02/06/87	4,297	270.08	4,027
				03/07/97	4,297	276.06	4,021
76	342258103150501	02N.35E.22.24344	I	01/27/82	4,258	269.80	3,988
77	342300103175001	---	O	02/29/04	4,270.11	294.97	3,975.14
		(Monitoring well Oa)		05/26/04	4,270.11	297.12	3,972.99
				08/12/04	4,270.11	299.88	3,970.23
				10/21/04	4,270.11	298.75	3,971.36
				01/10/05	4,270.11	297.50	3,972.61
78	342304103174401	02N.35E.20.1432	O	06/27/95	4,269.26	281.15	3,988.11
		(Monitoring well O)		02/27/96	4,269.26	281.21	3,988.05
79	342306103142101	02N.35E.23.211311	I	01/20/67	4,267	260.80	4,006
				01/11/72	4,267	268.46	3,999
				01/07/77	4,267	276.92	3,990
				01/26/82	4,267	281.72	3,985
				01/15/87	4,267	284.58	3,982
80	342306103221801	02N.34E.21.24240	W	02/12/82	4,314	267.68	4,046
				02/06/87	4,314	270.06	4,044
81	342307103181601	02N.35E.19.241	O	09/13/93	4,275.98	278.40	3,997.58
		(Monitoring well H)		06/27/95	4,275.98	280.35	3,995.63
				04/17/96	4,275.98	281.20	3,994.78
				06/25/96	4,275.98	282.15	3,993.83
				08/19/96	4,275.98	283.38	3,992.60
				08/19/97	4,275.98	283.68	3,992.30
				04/06/98	4,275.98	284.31	3,991.67
				03/02/99	4,275.98	286.66	3,989.32
				08/31/99	4,275.98	287.22	3,988.76
				03/02/00	4,275.98	287.68	3,988.30
				03/22/01	4,275.98	290.04	3,985.94
				03/12/02	4,275.98	291.37	3,984.61

Table I–2. Altitudes of water levels in selected wells at Cannon Air Force Base and the surrounding area.—Continued

[Monitoring well, Cannon Air Force Base monitoring well; Primary use of water: I, irrigation; O, observation; S, stock watering; U, unused; Z, other; W, withdrawal; ---, not recorded]

Map identifier (fig. I–1)	U.S. Geological Survey identifier	Township and range	Primary use of water	Water-level date	Altitude of land surface (feet above NAVD 88)	Water level (feet below land surface)	Altitude of water level (feet above NAVD 88)
				03/20/03	4,275.98	294.07	3,981.91
				04/02/03	4,275.98	294.00	3,981.98
				02/27/04	4,275.98	292.98	3,983.00
				05/26/04	4,275.98	296.22	3,979.76
				06/15/04	4,275.98	296.53	3,979.45
				08/12/04	4,275.98	296.94	3,979.04
				10/21/04	4,275.98	297.51	3,978.47
				01/10/05	4,275.98	297.05	3,978.93
82	342309103180601	02N.35E.19.242 (Monitoring well P)	O	07/15/95	4,270.55	275.99	3,994.56
				07/24/95	4,270.55	276.13	3,994.42
				08/23/95	4,270.55	276.48	3,994.07
				02/27/96	4,270.55	276.45	3,994.10
				04/16/96	4,270.55	277.06	3,993.49
				06/25/96	4,270.55	278.33	3,992.22
83	342310103160901	02N.35E.21.221122	I	01/06/56	4,276	240.20	4,036
				01/11/57	4,276	241.90	4,034
				01/13/58	4,276	244.65	4,031
				01/14/59	4,276	241.88	4,034
				01/15/60	4,276	242.61	4,033
				01/19/61	4,276	243.07	4,033
				01/05/62	4,276	244.09	4,032
				01/14/64	4,276	250.83	4,025
				02/17/65	4,276	249.02	4,027
				01/10/68	4,276	253.97	4,022
				01/07/69	4,276	256.11	4,020
				01/06/70	4,276	257.14	4,019
				01/06/71	4,276	273.26	4,003
				01/05/72	4,276	261.08	4,015
				01/04/73	4,276	262.75	4,013
				01/04/75	4,276	269.92	4,006
				01/06/76	4,276	268.50	4,008
				01/05/77	4,276	282.36	3,994
				01/06/79	4,276	270.34	4,006
				01/07/80	4,276	271.68	4,004
				01/10/81	4,276	284.08	3,992
				01/11/82	4,276	273.44	4,003
				01/10/83	4,276	274.03	4,002
				01/16/84	4,276	274.04	4,002
				01/14/85	4,276	274.55	4,001
				01/13/86	4,276	278.98	3,997
				01/12/87	4,276	275.15	4,001
				01/12/88	4,276	275.80	4,000
84	342310103165901	02N.35E.21.11111	I	02/10/54	4,276	232.87	4,043
				01/30/55	4,276	233.66	4,042

Table I–2. Altitudes of water levels in selected wells at Cannon Air Force Base and the surrounding area.—Continued

[Monitoring well, Cannon Air Force Base monitoring well; Primary use of water: I, irrigation; O, observation; S, stock watering; U, unused; Z, other; W, withdrawal; ---, not recorded]

Map identifier (fig. I–1)	U.S. Geological Survey identifier	Township and range	Primary use of water	Water-level date	Altitude of land surface (feet above NAVD 88)	Water level (feet below land surface)	Altitude of water level (feet above NAVD 88)
				01/07/77	4,276	269.04	4,007
				02/04/82	4,276	269.79	4,006
				01/16/87	4,276	271.03	4,005
				02/21/97	4,276	285.38	3,991
				03/04/04	4,276	292.47	3,984
85	342310103180801	---	O	02/27/04	4,270.85	290.00	3,980.85
		(Monitoring well Pa)		05/26/04	4,270.85	291.46	3,979.39
				08/12/04	4,270.85	292.82	3,978.03
				10/21/04	4,270.85	293.20	3,977.65
				01/10/05	4,270.85	292.37	3,978.48
86	342313103180801	02N.35E.19.224	O	09/13/94	4,276.46	279.31	3,997.15
		(Monitoring well G)		06/27/95	4,276.46	281.08	3,995.38
				04/17/96	4,276.46	281.89	3,994.57
				06/25/96	4,276.46	282.86	3,993.60
				08/19/96	4,276.46	283.96	3,992.50
				08/20/97	4,276.46	284.46	3,992.00
				04/06/98	4,276.46	284.83	3,991.63
				03/02/99	4,276.46	287.03	3,989.43
				08/31/99	4,276.46	287.60	3,988.86
				03/02/00	4,276.46	287.99	3,988.47
				03/22/01	4,276.46	290.34	3,986.12
				03/14/02	4,276.46	291.59	3,984.87
				03/20/03	4,276.46	294.44	3,982.02
				02/27/04	4,276.46	293.19	3,983.27
				05/26/04	4,276.46	295.53	3,980.93
				06/15/04	4,276.46	296.87	3,979.59
				08/12/04	4,276.46	297.52	3,978.94
				10/21/04	4,276.46	298.07	3,978.39
				01/10/05	4,276.46	297.33	3,979.13
87	342317103174701	02N.35E.20.123	O	06/27/95	4,265.88	273.31	3,992.57
		(Monitoring well N)		02/27/96	4,265.88	273.59	3,992.29
				11/05/03	4,265.88	287.78	3,978.10
				02/27/04	4,265.88	284.92	3,980.96
				05/26/04	4,265.88	288.33	3,977.55
				08/12/04	4,265.88	291.25	3,974.63
				10/21/04	4,265.88	289.47	3,976.41
				01/10/05	4,265.88	287.76	3,978.12
88	342320103142501	02N.35E.23.21113	I	03/06/62	4,267	249.91	4,017.00
89	342321103181001	02N.35E.19.222	O	09/12/94	4,274.93	276.99	3,997.94
		(Monitoring well F)		06/27/95	4,274.93	278.91	3,996.02
				04/16/96	4,274.93	279.17	3,995.76
				06/26/96	4,274.93	280.50	3,994.43

Table I–2. Altitudes of water levels in selected wells at Cannon Air Force Base and the surrounding area.—Continued

[Monitoring well, Cannon Air Force Base monitoring well; Primary use of water: I, irrigation; O, observation; S, stock watering; U, unused; Z, other; W, withdrawal; ---, not recorded]

Map identifier (fig. I–1)	U.S. Geological Survey identifier	Township and range	Primary use of water	Water-level date	Altitude of land surface (feet above NAVD 88)	Water level (feet below land surface)	Altitude of water level (feet above NAVD 88)
				08/19/96	4,274.93	282.39	3,992.54
				08/20/97	4,274.93	281.75	3,993.18
				04/06/98	4,274.93	282.21	3,992.72
				03/02/99	4,274.93	284.30	3,990.63
				08/31/99	4,274.93	284.74	3,990.19
				03/20/00	4,274.93	285.15	3,989.78
				03/22/01	4,274.93	287.41	3,987.52
				08/21/01	4,274.93	287.81	3,987.12
				03/14/02	4,274.93	289.23	3,985.70
				03/18/03	4,274.93	291.53	3,983.40
				02/27/04	4,274.93	289.78	3,985.15
				05/26/04	4,274.93	293.99	3,980.94
				06/16/04	4,274.93	294.29	3,980.64
				08/12/04	4,274.93	294.96	3,979.97
				10/21/04	4,274.93	295.64	3,979.29
				01/10/05	4,274.93	294.64	3,980.29
90	342323103145601	02N.35E.23.111	U	01/10/83	4,279	289.73	3,989
				01/19/84	4,279	290.74	3,988
				01/14/85	4,279	293.12	3,986
				01/13/86	4,279	293.89	3,985
				01/12/87	4,279	294.95	3,984
				01/13/88	4,279	292.25	3,987
				01/04/90	4,279	294.15	3,985
				01/05/91	4,279	294.71	3,984
				01/02/92	4,279	298.90	3,980
				01/08/93	4,279	300.47	3,979
				01/05/94	4,279	304.31	3,975
				01/05/95	4,279	316.26	3,963
				01/11/96	4,279	299.81	3,979
				01/17/97	4,279	301.01	3,978
				01/08/98	4,279	301.63	3,977
91	342323103180801	02N.35E.20.111 (Monitoring well Ra)	O	05/26/04	4,272.31	291.85	3,980.46
				08/12/04	4,272.31	293.18	3,979.13
				10/21/04	4,272.31	293.83	3,978.48
				01/10/05	4,272.31	292.40	3,979.91
92	342324103211401	02N.34E.23.11111	I	02/17/82	4,317	287.62	4,029
				02/05/87	4,317	290.39	4,027
93	342325103233601	02N.34E.17.43444	I	02/12/82	4,334	265.47	4,069
				02/06/87	4,334	251.50	4,083
94	342328103182401	02N.35E.18.434 (Monitoring well E)	O	09/13/94	4,279.70	280.55	3,999.15
				06/27/95	4,279.70	282.56	3,997.14
				04/16/96	4,279.70	283.70	3,996.00

Table I–2. Altitudes of water levels in selected wells at Cannon Air Force Base and the surrounding area.—Continued

[Monitoring well, Cannon Air Force Base monitoring well; Primary use of water: I, irrigation; O, observation; S, stock watering; U, unused; Z, other; W, withdrawal; ---, not recorded].

Map identifier (fig. I–1)	U.S. Geological Survey identifier	Township and range	Primary use of water	Water-level date	Altitude of land surface (feet above NAVD 88)	Water level (feet below land surface)	Altitude of water level (feet above NAVD 88)
				06/24/96	4,279.70	284.32	3,995.38
				08/19/96	4,279.70	284.68	3,995.02
				08/19/97	4,279.70	285.23	3,994.47
				04/06/98	4,279.70	285.77	3,993.93
				03/02/99	4,279.70	287.85	3,991.85
				08/31/99	4,279.70	288.19	3,991.51
				03/02/00	4,279.70	288.74	3,990.96
				03/15/00	4,279.70	288.93	3,990.77
				03/22/01	4,279.70	291.04	3,988.66
				03/12/02	4,279.70	292.33	3,987.37
				03/21/03	4,279.70	294.82	3,984.88
				02/27/04	4,279.70	294.10	3,985.60
				05/26/04	4,279.70	297.27	3,982.43
				06/16/04	4,279.70	297.66	3,982.04
				08/12/04	4,279.70	298.01	3,981.69
				10/21/04	4,279.70	298.66	3,981.04
				01/10/05	4,279.70	297.99	3,981.71
95	342338103203701	02N.34E.14.41112	I	01/23/67	4,329	273.89	4,055
				01/11/72	4,329	286.40	4,043
				01/05/77	4,329	295.70	4,033
				02/17/82	4,329	305.74	4,023
				02/06/87	4,329	308.89	4,020
				03/07/97	4,329	312.50	4,017
				03/05/04	4,329	319.77	4,009
96	342338103210701	02N.34E.14.31121	Z	02/27/62	4,337	268.46	4,069
97	342344103224901	02N.34E.16.32422	I	02/17/82	4,330	285.43	4,045
				02/06/87	4,330	280.02	4,050
				03/13/92	4,330	284.05	4,046
98	342348103175801	02N.35E.17.3121 (Monitoring well W)	O	02/27/04	4,296.95	311.49	3,985.46
				03/11/04	4,296.95	314.32	3,982.63
				04/29/04	4,296.95	314.81	3,982.14
				05/26/04	4,296.95	315.80	3,981.15
				06/15/04	4,296.95	316.44	3,980.51
				08/12/04	4,296.95	317.18	3,979.77
				10/21/04	4,296.95	317.91	3,979.04
				01/10/05	4,296.95	315.33	3,981.62
99	342353103214601	02N.34E.15.14442	I	02/18/82	4,341	310.01	4,031
100	342358103151601	02N.35E.15.232411	U	10/27/77	4,309	315.55	3,993
				01/28/82	4,309	317.39	3,992
				01/15/87	4,309	319.40	3,990
101	342401103155901	02N.35E.15.13111	I	01/28/82	4,314	314.71	3,999
				01/15/87	4,314	316.76	3,997

Table I–2. Altitudes of water levels in selected wells at Cannon Air Force Base and the surrounding area.—Continued

[Monitoring well, Cannon Air Force Base monitoring well; Primary use of water: I, irrigation; O, observation; S, stock watering; U, unused; Z, other; W, withdrawal; ---, not recorded]

Map identifier (fig. I–1)	U.S. Geological Survey identifier	Township and range	Primary use of water	Water-level date	Altitude of land surface (feet above NAVD 88)	Water level (feet below land surface)	Altitude of water level (feet above NAVD 88)
102	342404103210401	02N.34E.14.11121	I	01/30/67	4,353	301.75	4,051
				01/13/72	4,353	316.85	4,036
				01/05/77	4,353	325.47	4,028
				02/16/82	4,353	336.21	4,017
				02/05/87	4,353	338.90	4,014
103	342405103170301	02N.35E.17.22442	I	02/10/82	4,305	295.29	4,010
				01/27/87	4,305	297.58	4,007
104	342405103235001	02N.34E.17.122224	---	01/23/67	4,357	265.65	4,091
				01/12/72	4,357	268.23	4,089
105	342406103183401	02N.35E.07.34442	W	03/07/62	4,325	274.13	4,051
				01/11/72	4,325	293.78	4,031
106	342418103180601	02N.35E.07.44442	W	02/16/82	4,315	298.66	4,016
				01/16/87	4,315	303.97	4,011
				02/21/97	4,315	309.55	4,005
107	342418103201201	02N.34E.13.1111 (Monitoring well V)	O	11/06/03	4,324.82	330.30	3,994.52
				01/16/04	4,324.82	330.04	3,994.78
				03/11/04	4,324.82	330.59	3,994.23
				04/20/04	4,324.82	330.31	3,994.51
				06/14/04	4,324.82	330.64	3,994.18
				10/21/04	4,324.82	331.04	3,993.78
				01/10/05	4,324.82	330.74	3,994.08
108	342419103232301	02N.34E.08.442114	I	01/05/77	4,362	297.19	4,065
				02/18/82	4,362	299.48	4,063
				02/04/87	4,362	297.05	4,065
				03/07/97	4,362	301.18	4,061
109	342424103220901	02N.34E.10.332333	I	02/05/87	4,363	338.06	4,025
				04/28/87	4,363	337.54	4,025
110	342435103223501	O2N.34.E.09.400	U	---	4,364	---	---
111	342442103213601	02N.34E.10.23124	I	03/06/62	4,365	293.12	4,072
				01/24/67	4,365	308.65	4,056
				02/01/68	4,365	311.05	4,054
				01/08/69	4,365	313.46	4,052
				01/07/70	4,365	316.59	4,048
				01/05/71	4,365	318.78	4,046
				01/04/72	4,365	324.42	4,041
				01/03/74	4,365	333.66	4,031
				01/04/75	4,365	336.68	4,028
				01/04/77	4,365	341.00	4,024
				01/05/77	4,365	351.40	4,014
				03/16/77	4,365	337.04	4,028
				01/06/79	4,365	341.74	4,023
112	342453103141901	02N.35E.11.21111	I	01/25/77	4,319	323.40	3,996

Table I–2. Altitudes of water levels in selected wells at Cannon Air Force Base and the surrounding area.—Continued

[Monitoring well, Cannon Air Force Base monitoring well; Primary use of water: I, irrigation; O, observation; S, stock watering; U, unused; Z, other; W, withdrawal; ---, not recorded]

Map identifier (fig. I–1)	U.S. Geological Survey identifier	Township and range	Primary use of water	Water-level date	Altitude of land surface (feet above NAVD 88)	Water level (feet below land surface)	Altitude of water level (feet above NAVD 88)
				01/26/82	4,319	323.95	3,995
				01/15/87	4,319	324.68	3,994
113	342455103183301	02N.35E.07.122221	I	01/11/72	4,344	311.90	4,032
114	342456103195201	02N.34E.12.11222	I	03/14/62	4,354	266.57	4,087
				02/01/63	4,354	298.18	4,056
				01/24/67	4,354	307.69	4,046
				01/31/72	4,354	317.67	4,036
				01/04/77	4,354	333.25	4,021
				02/16/82	4,354	346.37	4,008
				01/27/87	4,354	348.53	4,005
115	342457103213901	02N.34E.10.21112	I	01/31/72	4,365	322.52	4,042
				01/04/77	4,365	338.29	4,027
				01/07/80	4,365	344.82	4,020
				01/12/81	4,365	348.93	4,016
				01/11/82	4,365	348.71	4,016
				01/09/83	4,365	350.54	4,014
				01/18/84	4,365	351.21	4,014
				01/13/85	4,365	349.98	4,015
				01/13/87	4,365	349.01	4,016
				01/04/91	4,365	348.73	4,016
				01/02/92	4,365	347.73	4,017
				01/05/93	4,365	347.11	4,018
				01/17/97	4,365	354.77	4,010
116	342505103151801	02N.35E.10.21111	I	03/03/62	4,336	303.74	4,032
				02/03/67	4,336	326.32	4,010
				02/01/68	4,336	323.63	4,012
				01/08/69	4,336	326.12	4,010
				01/08/70	4,336	326.38	4,010
				01/09/71	4,336	331.36	4,005
				01/05/72	4,336	334.21	4,002
				01/11/72	4,336	334.49	4,002
				01/04/73	4,336	334.22	4,002
				01/04/74	4,336	337.65	3,998
				01/04/75	4,336	345.22	3,991
				01/07/76	4,336	350.19	3,986
				01/05/77	4,336	361.74	3,974
				01/07/77	4,336	338.05	3,998
				03/16/77	4,336	338.44	3,998
				01/06/79	4,336	338.96	3,997
				01/08/80	4,336	340.03	3,996
				01/12/81	4,336	340.23	3,996
				01/09/82	4,336	339.02	3,997

Table I–2. Altitudes of water levels in selected wells at Cannon Air Force Base and the surrounding area.—Continued

[Monitoring well, Cannon Air Force Base monitoring well; Primary use of water: I, irrigation; O, observation; S, stock watering; U, unused; Z, other; W, withdrawal; ---, not recorded]

Map identifier (fig. I–1)	U.S. Geological Survey identifier	Township and range	Primary use of water	Water-level date	Altitude of land surface (feet above NAVD 88)	Water level (feet below land surface)	Altitude of water level (feet above NAVD 88)
				01/10/83	4,336	338.54	3,997
				01/18/84	4,336	339.05	3,997
				01/13/85	4,336	337.77	3,998
				01/11/86	4,336	338.94	3,997
				01/13/87	4,336	338.39	3,998
				01/12/88	4,336	337.62	3,998
				01/04/91	4,336	340.74	3,995
				01/03/92	4,336	340.65	3,995
				01/05/93	4,336	340.06	3,996
				01/05/94	4,336	341.19	3,995
				01/04/95	4,336	342.39	3,994
				01/11/96	4,336	343.59	3,992
				01/06/98	4,336	344.64	3,991
117	342506103164701	02N.35E.09.12111	I	01/29/82	4,345	348.38	3,997
				01/16/87	4,345	346.29	3,999
118	342506103174201	02N.35E.08.12211	I	01/29/82	4,349	329.92	4,019
				01/16/87	4,349	330.39	4,019
119	342509103203801	02N.34E.02.43111	I	01/04/77	4,369	340.77	4,028
				02/05/87	4,369	356.62	4,012
120	342519103230101	02N.34E.04.32133	I	03/03/62	4,394	313.16	4,081
				01/24/67	4,394	326.38	4,068
				02/01/68	4,394	331.65	4,062
				01/08/69	4,394	336.44	4,058
				01/07/70	4,394	337.87	4,056
				01/07/71	4,394	342.15	4,052
				01/04/72	4,394	352.37	4,042
				01/03/73	4,394	353.37	4,041
				01/03/74	4,394	352.81	4,041
				01/03/75	4,394	360.02	4,034
				01/06/76	4,394	367.78	4,026
				01/05/77	4,394	364.06	4,030
				01/08/78	4,394	368.60	4,025
				01/06/79	4,394	365.88	4,028
				01/07/80	4,394	366.77	4,027
				01/12/81	4,394	371.56	4,022
				01/11/82	4,394	368.25	4,026
				01/09/83	4,394	369.17	4,025
				01/13/85	4,394	368.22	4,026
				01/11/86	4,394	366.96	4,027
121	342520103165601	02N.35E.04.31111	I	04/21/54	4,356	295.49	4,061
				01/29/55	4,356	300.79	4,055
				01/09/56	4,356	303.90	4,052

Table I–2. Altitudes of water levels in selected wells at Cannon Air Force Base and the surrounding area.—Continued

[Monitoring well, Cannon Air Force Base monitoring well; Primary use of water: I, irrigation; O, observation; S, stock watering; U, unused; Z, other; W, withdrawal; ---, not recorded].

Map identifier (fig. I–1)	U.S. Geological Survey identifier	Township and range	Primary use of water	Water-level date	Altitude of land surface (feet above NAVD 88)	Water level (feet below land surface)	Altitude of water level (feet above NAVD 88)
				01/15/57	4,356	306.07	4,050
				01/22/58	4,356	306.98	4,049
				01/19/61	4,356	308.17	4,048
				01/17/62	4,356	308.80	4,047
				01/14/64	4,356	313.46	4,043
				02/17/65	4,356	317.32	4,039
				01/07/71	4,356	331.56	4,024
				01/26/77	4,356	346.41	4,010
122	342521103221801	02N.34E.04.44222	I	02/18/82	4,381	359.73	4,021
				02/05/87	4,381	358.32	4,023
123	342522103203801	02N.34E.02.41111	Z	03/03/62	4,373	302.23	4,071
				01/24/67	4,373	320.75	4,052
				01/31/72	4,373	329.04	4,044
124	342523103225301	02N.34E.04.32211	I	01/04/77	4,391	361.26	4,030
125	342532103180501	02N.35E.05.31111	I	01/29/82	4,362	342.88	4,019
				01/16/87	4,362	343.18	4,019
				02/21/97	4,362	344.66	4,017
126	342533103145601	02N.35E.02.13333	I	01/29/82	4,335	334.91	4,000
				01/16/87	4,335	335.44	4,000
127	342535103190201	02N.35E.06.31211	I	01/29/82	4,360	334.52	4,025
				01/30/87	4,360	334.71	4,025
128	342535103211501	02N.34E.03.20000	I	02/18/82	4,391	365.33	4,026
				02/05/87	4,391	365.91	4,025
129	342547103190201	02N.35E.06.11111	I	03/03/62	4,375	307.15	4,068
130	342548103193601	02N.34E.01.12222	I	03/14/62	4,384	315.37	4,069
				01/24/67	4,384	320.26	4,064
				02/01/68	4,384	325.65	4,058
				01/08/69	4,384	329.27	4,055
				01/07/70	4,384	331.00	4,053
				01/05/71	4,384	333.45	4,051
				01/05/72	4,384	336.75	4,047
				01/11/72	4,384	334.70	4,049
				01/03/73	4,384	336.12	4,048
				01/03/74	4,384	342.14	4,042
				01/03/75	4,384	338.13	4,046
				01/06/76	4,384	339.70	4,044
				01/04/77	4,384	341.82	4,042
				01/05/77	4,384	341.63	4,042
				01/07/78	4,384	342.04	4,042
				01/06/79	4,384	341.77	4,042
				01/07/80	4,384	342.35	4,042
				01/12/81	4,384	342.91	4,041

Table I–2. Altitudes of water levels in selected wells at Cannon Air Force Base and the surrounding area.—Continued

[Monitoring well, Cannon Air Force Base monitoring well; Primary use of water: I, irrigation; O, observation; S, stock watering; U, unused; Z, other; W, withdrawal; ---, not recorded].

Map identifier (fig. I–1)	U.S. Geological Survey identifier	Township and range	Primary use of water	Water-level date	Altitude of land surface (feet above NAVD 88)	Water level (feet below land surface)	Altitude of water level (feet above NAVD 88)
				01/11/82	4,384	342.78	4,041
				01/09/83	4,384	342.18	4,042
				01/18/84	4,384	342.19	4,042
				01/13/85	4,384	341.76	4,042
				01/13/87	4,384	341.91	4,042
				01/12/88	4,384	341.44	4,043
				01/04/91	4,384	342.36	4,042
				01/02/92	4,384	341.91	4,042
				01/05/93	4,384	341.73	4,042
				01/05/94	4,384	341.04	4,043
				01/05/95	4,384	341.81	4,042
				01/17/97	4,384	343.63	4,040
				03/03/04	4,384	348.09	4,036
131	342551103232201	02N.34E.05.242	I	---	4,400	---	---
132	342559103155601	03N.35E.34.33333	I	01/13/87	4,357	344.91	4,012
133	342559103165301	03N.35E.33.33344	I	02/23/82	4,366	354.57	4,011
				01/13/87	4,366	354.88	4,011
134	342559103183401	03N.35E.31.43333	I	02/23/82	4,370	345.90	4,024
				01/13/87	4,370	333.18	4,037
				04/03/87	4,370	333.10	4,037
135	342600103232001	02N.34E.05.22222	I	02/18/82	4,409	377.17	4,032
				01/27/87	4,409	372.23	4,037
136	342609103172701	03N.35E.32.41131	I	03/16/77	4,381	347.29	4,034
				02/23/82	4,381	351.00	4,030
				01/13/87	4,381	352.56	4,028
137	342615103220701	03N.34E.34.31122	I	03/03/62	4,424	308.85	4,115
				01/30/63	4,424	311.55	4,112
				02/01/72	4,424	364.33	4,060
				01/13/77	4,424	378.20	4,046
				02/26/82	4,424	388.71	4,035
				01/13/87	4,424	388.20	4,036
				03/07/97	4,424	391.58	4,032
138	342626103195301	03N.34E.36.32111	I	02/10/82	4,394	343.00	4,051
139	342626103204101	03N.34E.35.41111	I	02/26/82	4,407	349.04	4,058
140	342630103145201	03N.35E.35.31111	I	04/21/54	4,347	295.49	4,052
				01/09/56	4,347	303.31	4,044
				01/16/57	4,347	304.24	4,043
				01/22/58	4,347	302.98	4,044
				01/19/59	4,347	301.86	4,045
				01/19/61	4,347	304.06	4,043
				01/17/62	4,347	304.15	4,043
				01/22/63	4,347	307.21	4,040

Table I–2. Altitudes of water levels in selected wells at Cannon Air Force Base and the surrounding area.—Continued

[Monitoring well, Cannon Air Force Base monitoring well; Primary use of water: I, irrigation; O, observation; S, stock watering; U, unused; Z, other; W, withdrawal; ---, not recorded].

Map identifier (fig. I–1)	U.S. Geological Survey identifier	Township and range	Primary use of water	Water-level date	Altitude of land surface (feet above NAVD 88)	Water level (feet below land surface)	Altitude of water level (feet above NAVD 88)
				01/14/64	4,347	310.69	4,036
				01/12/66	4,347	314.65	4,032
				01/11/68	4,347	322.00	4,025
				02/04/77	4,347	327.84	4,019
141	342630103231901	03N.34E.33.13331	I	02/10/82	4,422	385.60	4,036
				01/08/87	4,422	379.19	4,043
142	342633103155301	03N.35E.34.11133	I	01/06/71	4,369	328.16	4,041
				01/27/72	4,369	332.35	4,037
				01/04/73	4,369	336.07	4,033
				01/03/74	4,369	333.50	4,036
				01/04/75	4,369	336.32	4,033
				01/07/76	4,369	332.60	4,036
				01/05/77	4,369	333.84	4,035
				01/07/78	4,369	333.65	4,035
				01/06/79	4,369	334.52	4,034
				01/08/80	4,369	338.80	4,030
				01/12/81	4,369	343.77	4,025
				02/23/82	4,369	342.44	4,027
				01/10/83	4,369	342.98	4,026
				01/18/84	4,369	340.54	4,028
				01/11/85	4,369	338.58	4,030
				01/13/87	4,369	340.02	4,029
				01/12/88	4,369	340.19	4,029
				01/04/90	4,369	346.77	4,022
				01/04/91	4,369	343.99	4,025
				01/02/92	4,369	343.46	4,026
				01/07/94	4,369	351.84	4,017
				01/22/97	4,369	345.31	4,024
				03/12/02	4,369	346.36	4,023
				03/11/04	4,369	348.68	4,020
143	342638103162401	03N.35E.33.21111	I	03/03/62	4,378	313.75	4,064
				01/19/67	4,378	323.10	4,055
				02/04/77	4,378	335.40	4,043
144	342653103195201	03N.34E.25.33222	I	01/20/69	4,406	322.03	4,084
				01/27/72	4,406	325.88	4,080
				01/13/77	4,406	330.27	4,076
				02/26/82	4,406	334.62	4,071
				01/13/87	4,406	336.15	4,070
145	342655103151401	03N.35E.27.43414	I	02/19/82	4,364	331.82	4,032
				01/13/87	4,364	332.40	4,032

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